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EVACUATION RISKS. AN EVALUATION

Joseph M. Hans, Jr., et al

National Environmental Research Center
Las Vegas, Nevada

June 1974

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EVACUATION RISKS-AN EVALUATION

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Thomas C. Sell

June 1974

U. S. ENVIRONMENTAL PROTECTION AGENCY
Office of Radiation Programs
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Las Vegas, Nevada 89114

FOREWORD

The Office of Radiation Programs carries out a National program designed to evaluate the exposure of man to ionizing and non-ionizing radiation and to promote development of controls necessary to protect the public health and safety and assure environmental quality.

Within the Office of Radiation Programs, problem areas have been defined and assigned a priority in order to determine the level of effort expended in each area. One of these, the Accident Problem Area, has been assigned a high priority and requires the participation and cooperation of several Federal agencies. Each agency has been assigned specific tasks as outlined in an interagency agreement. This report is directed at a specific Environmental Protection Agency task of establishing action guidelines based on radiation exposure levels which might result from nuclear incidents. Other reports, recommendations, and state assistance will be developed and executed to fulfill EPA obligations under the interagency agreement.

I encourage users of this report to inform the Office of Radiation Programs of any omissions or errors. Your additional comments or requests for further information are also solicited.

W. D. Rowe

W. D. Rowe, Ph.D.
Deputy Assistant Administrator
for Radiation Programs

PREFACE

In the event of an incident at a fixed nuclear facility which can cause or potentially cause radiation exposure to the public in the vicinity of the facility, appropriate protective measures must be identified which will substantially reduce or avert the exposures. One of these protective measures is to evacuate the public from the affected area.

Evacuation, like radiation exposure, can impose risks upon the affected population group. These risks should not exceed the risks from radiation exposure that would otherwise occur if no evacuation took place. Although the risks from radiation exposure can be estimated to some degree, no evacuation risk studies have been available to provide a basis for decisions concerning the application of this protective action.

This report was initiated to provide a needed assessment of evacuation risks in order that the Office of Radiation Programs can promulgate Protective Action Guides for evacuation based on risk analysis. Parts of the report and ensuing guides, along with other useful information, will be incorporated into a manual for those who have responsibilities for the management of radiation incidents.

Charles L Weaver

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Director, Field Operations Division
Office of Radiation Programs

ACKNOWLEDGEMENT

The authors acknowledge the information, assistance, and cooperation provided by members of the Headquarters of the Defense Civil Preparedness Agency (DCPA), DCPA Regional Offices, State Civil Defense and Emergency Services, and especially those persons on the local civil defense level without whose support this document could not have been prepared.

Many other organizations on the Federal, state, and local levels have contributed information and data used throughout the report. These include: American Red Cross, U.S. Army National Guard, Salvation Army, National Academy of Sciences, Office of Emergency Preparedness, Atomic Industrial Forum, Inc., Disaster Research Center of The Ohio State University, Department of Commerce, Department of Transportation, Systems Development Coporation, National Safety Council, U.S. Coast Guard, Institute for Defense Analysis, and Stanford Research Council.

Special acknowledgement is given to Donald L. Lambdin, Office of Radiation Programs--Las Vegas, for his assistance in preparing this report.

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ABSTRACT

A study was conducted to assess the risk of death, injury, and cost associated with an evacuation of population groups affected by an incident at a fixed nuclear facility. Data and information were obtained by contacting persons and organizations involved with previous evacuations precipitated by natural or man-made causes and from available literature on the subject. Frequencies of 8.9×10^{-8} deaths per person-mile and 4.4×10^{-8} injuries per person-mile were derived from data representing vehicle evacuations involving approximately 5.5×10^{5} persons. National Safety Council (NSC) data for motor vehicle accidents indicate frequencies of 2.4×10^{-8} deaths per person-mile and 9.0×10^{-7} injuries per person-mile. Because of the small number of deaths and injuries derived from the study of evacuations, no statistical comparison with NSC information could be made; however, strong subjective information suggests that NSC data can be used for estimating the risk of injury or death.

Only some fragmentary costs related to the evacuation process were obtained from data sources, and total costs had to be constructed from available literature. Aspects, other than risk and cost, concerning evacuations are also discussed in the report.

EVACUATION RISKS—AN EVALUATION

INTRODUCTION

Considerable attention has been given to methods of protecting the general public from radiation exposure in the event of accidents at nuclear power plants. In the power plant licensing process, the Atomic Energy Commission (AEC) requires an evaluation of the consequences of a series of postulated accidents. This involves the determination, with the use of appropriate assumptions, of the dose equivalent (H) that potentially could be received by members of the public as a result of the postulated accidents. A proposed site, from an accident viewpoint, is considered acceptable by the AEC if the calculated H does not exceed the H criteria specified in 10-CFR-100 (1).

License applicants are required to submit detailed plans for coping with emergencies and accidents which could affect members of the public around power plant sites.

The licensees are also required to make contacts and arrangements for emergency support with local, state, and Federal agencies that have responsibilities for responding to the emergencies.

In order to provide a more formalized, coordinated Federal approach for emergency response planning for fixed nuclear facilities, the Director, Office of Emergency Preparedness (OEP) issued, in the Federal Register, an agreement among Federal agencies which delegated to each participating agency certain responsibilities (2). The Environmental Protection Agency (EPA) is responsible for the following:

1. Establishing action guidelines based on projected radiation exposure levels which might result from nuclear incidents.

2. Recommending appropriate protective measures which can be taken by governmental authorities to minimize the consequences of an incident and reduce the potential population exposure.

3. Assisting state health departments and other state agencies that have responsibilities for radiological response in developing their emergency plans, following the AEC guidelines.

Some guidance applicable to items 1 and 2 is available from the former Federal Radiation Council (FRC) in its Reports 5 and 7 (3,4). The guidance is in terms of Protective Action Guides (PAG) and Protective Actions (herein often called protective measures). A PAG is defined as "The projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event."

The PAG's were presented as numerical values of absorbed dose to the whole body and some body organs. The application of the guides requires that absorbed dose be projected or estimated before it is actually received. If absorbed dose projections exceed the numerical guides, a protective action is warranted. Such a protective action is an action that would avert most of the absorbed dose that a potentially affected population group would receive.

Many considerations, including health, were used by the FRC in setting the numerical values of the PAG's. Also, the application of protective actions were to be based upon a risk-versus-benefit analysis which was not numerically defined. The approach in setting Protective Action Guides should be based initially on biological risk and, then, adjustments of the guides or protective actions made on a cost-risk-benefit analysis. Contemporary epidemiological and radiobiological research has provided information and data which permit the estimation of health risks associated with radiation exposure. Any protective measures that may be initiated will also present some risks which, at present, have not been fully assessed. An evaluation of protective action risks can lead to methodology for the comparison of these risks with the risks of radiation exposure. This comparison could provide a basis for decisions concerning the application of protective actions.

OBJECTIVES

A variety of protective measures (5) are available to minimize absorbed dose to the population in the event of a nuclear accident which would release radioactivity to the environment. In general, the selection of a particular protective action or a combination of actions will be dependent upon characteristics of the area and population at risk as well as the nature of the incident.

One protective action that may be applied is evacuation of the threatened area. There are two types of evacuations. The first is to evacuate people from unprotected outdoor areas to indoor locations within the potentially affected geographical area. This type of evacuation will not completely avoid a projected absorbed dose but will reduce it by "shielding" and by reducing the amount of inhaled radioactivity. Estimates of protection factors for various structures based upon the expected radionuclide content of an accidental reactor release are under study as a separate investigation.

The second type of evacuation is to move persons outside the boundaries of the potentially affected geographical area. If this is done promptly and correctly, a substantial reduction of dose should result.

The Environmental Protection Agency is responsible for protecting public health and insuring the quality of the environment. Under this broad charter, the EPA's Office of Radiation Programs (ORP) has the authority and the responsibility to establish radiation exposure criteria for the general public in the event of a nuclear incident. This responsibility was further solidified by the OEP agreement (2). As a part of its overall radiation protection plan, ORP will develop Protective Action Guides to supplement those already promulgated by the former FRC. Interim Protective Action Guides for Evacuation have been issued by ORP (6).

The objectives of this study are to determine: the risk of death, major injury, and cost associated with an evacuation; what parameters in an evacuation affect risk; and, if such parameters exist, can they be used to prognosticate risk.

The monetary risk of an evacuation cannot be considered on an equal basis with health risks; however, it should be considered when establishing evacuation criteria. For example, higher permissible dose levels may be warranted for segments of the population whose evacuation would produce significantly increased total evacuation costs. This economic impact must be weighed against radiation dose savings. For this purpose, cost of evacuation is included in this report as a risk to be considered along with health risks. However, this does not imply that monetary values are being assigned to death or injury.

PROCEDURES

The initial phase of the study was to determine if evacuation risks had previously been established or were in the process of being established and, if so, were they applicable to this study. Two approaches were taken. The first was to review research in progress through the Smithsonian Science Information Exchange, Incorporated (SSIE), a national register of ongoing research. The second was to interrogate various national organizations (appendix D) to determine if they had made or were making any similar studies, or if they were aware of any organizations that had done so.

From these two major sources of information, it was learned that, although numerous studies, somewhat related to evacuations, had been conducted by different organizations, none had dealt directly with risks associated with evacuation. Apparently, in past evacuations, the risk from the immediate or potential emergency was obviously much greater than the assumed risk of evacuation. Consequently, there was no need to have evacuation risk information.

An additional literature search was requested for relevant information through the National Environmental Research Center--Cincinnati. This was a computer search of various information bases listed in appendix C. Personal visits were also made with personnel from the following organizations: Office of Emergency Preparedness, Defense Civil Preparedness Agency, U.S. Coast Guard, Office of Hazardous Materials (Department of Transportation), and Institute for Defense Analysis. These visits were made to discuss the study; to survey and borrow available literature or bibliographies; to be briefed on emergencies, disasters and planning for such events; and to receive general background information on the subject.

The acquired literature and information received from personal contacts provided much ancillary material on disasters and evacuations, but little was directly useful for the risk study. Based upon the fact that the risks associated with the evacuation of people had not been quantified and no information existed about the subject, it was determined that it would be necessary to investigate individual events of the past which required evacuations and to estimate the risks associated with the movement of these people.

Since no national register for disasters could be identified, it was necessary to compile a working list of various types of incidents that had occurred in the past which precipitated an evacuation. It was decided to include in the search only those events which occurred in the United States after 1960. Limiting the events to the United States would eliminate conditions in other countries which do not closely approximate circumstances in this country. It was also thought that if enough events occurred after 1960, events prior to this date would not be used. The basis for this decision was: 1) with the rapidity of changing conditions since 1960, events prior to this time would not approximate future situations as closely, and 2) it would be more difficult to locate people familiar with events prior to 1960.

Identification and compilation of a list of events requiring evacuation which occurred after 1960, regardless of the cause, was accomplished by searching available literature and contacting various organizations. From previous discussions with the Federal Defense Civil Preparedness Agency, it appeared that its Regional Offices would be an excellent source of information on occurrences within states in each region. Personnel in all eight Defense Civil Preparedness Agency Regional Offices were asked if they could provide a list of the events that occurred in their region which required an evacuation of 25 or more people and any supplemental information that was available concerning the events.

Overall, a list of about 500 events was compiled (appendix G). Although this is not a complete listing of all the events in the United States after 1960 which required an evacuation, it provided a sufficient number for survey purposes. There were also enough different causes for evacuations--floods, fires, hurricanes, explosions, toxic substances, etc.--to provide potentially useful comparisons.

The second phase of the study was to collect data on selected evacuation events. Not only was information desired on the deaths, injuries, and costs connected with each event, but also enough additional information was needed to determine what relationships might exist between various factors and what bearing these factors might have on risk. Parameters, such as weather, time, road conditions, etc., establishing the conditions under which an actual evacuation occurred, could also be related to the conditions which might exist at a nuclear power plant. A questionnaire was developed (appendix A) listing these parameters and the information needed in establishing the environment of a particular evacuation event.

From preliminary inquiries, it was determined that the best sources of information for most events would be the persons directly involved with the incident. Personnel associated with the incident were located and contacted by telephone and, in most cases, all information required on the questionnaire was completed. In some instances, where the information was not readily available, or persons could not be contacted by telephone, the questionnaire was mailed. Requests were also made for any reports which existed for the event. Not all key information was available or obtainable for some incidents; however, enough was obtained to permit analysis.

Since it was not possible to obtain a statistically random sample because of the many variables potentially involved, the selection of events was based primarily on judgment. The determination of which incidents to select for questionnaire completion was based on information initially available, such as the type of event, the number of evacuees, and the geographic location. In some cases, additional data in the form of reports was available to aid selection. All transportation accidents involving hazardous materials and an evacuation of more than 500 persons were investigated since it was thought their occurrence without warning would more closely approximate reactor accidents. Questionnaires on other events which had potentially short warning times were completed. A number of incidents involving floods and/or hurricanes were selected on the basis of numbers of people involved. Events were selected to cover a wide range of population sizes.

A summary of the information collected is presented in appendix B.

RESULTS

A list of incidents, which required the evacuation of people (appendix B), was collected covering the period from January 1960 until February 1973. Fifty-nine of these incidents were selected for investigation and a questionnaire completed on each. On seven of the incidents, multiple types of evacuations occurred and/or extremely large areas were involved. In these cases, multiple questionnaires were completed on the same incident in order to obtain more detailed information. A total of 70 questionnaires were completed.

Table 1 is a listing of the incidents categorized by the disaster agent and the total number of people evacuated for each category.

After examining the data collected, it was decided that six questionnaires and the information they contained would not be utilized in the summarization and data analysis. On event numbers 1, 2, and 3, involving 12 evacuees, not enough ancillary data was available. Event number 24, involving 101,000 persons evacuated, was a civil defense drill conducted prior to 1960. Event numbers 30a and 30b, totaling 100 evacuees, involved one hospital evacuated during a hurricane and are discussed separately, later in the report. Eliminating these events reduced the total number of incidents used for analysis to 54; questionnaires completed reduced to 64; and the total number of people evacuated reduced from 1,243,448 to 1,142,336.

Table 1

Incident Investigated by Category and Number of People Evacuated

Incident by Category	Number Investigated	Number of People Evacuated
Flood	33	93,340
Hurricane	14	735,858
Transportation	12	215,850
Tidal Wave	3	4,000
Dam Break	3	89,500
Nuclear Test	1	300
Landslide	1	150
Tornado (Flood)	1	3,400
Fire	1	50
Civil Defense Test	1	101,000
Total:	70	1,243,448

Note: Includes all incidents investigated; in subsequent data analysis six events, totaling 101,112 people, were not used.

Tables 2, 3, and 4 are a summary of the meteorological conditions, time of day, and road conditions of the evacuations. A sufficient number of events of approximately the same magnitude occurred in each of the two major divisions in each table, such that their effect on evacuation risks could be compared.

In analyzing the results of the questionnaire, it appeared that enough data was collected with sufficient variety of environmental conditions to determine the risk of death, injury, and cost and to determine the parameters which effect these risks.

With approximately 1,140,000 people evacuated in 64 events (a breakdown of size of population evacuated is given in table 5), the data should be a reasonable representation of the total incidents requiring evacuations which have occurred since 1960 in the United States. Although no estimate is available for the total number of evacuations and evacuees that have resulted from all contemporary disasters, it seems highly unlikely that the total number of people evacuated in recent times could be any higher than a factor of three or four over the study population. Although the total number of incidents requiring evacuation may be in the thousands, the number of people per evacuation is probably small (7,8).

Assuming that a 25 percent evacuation population sample was randomly obtained, the data collected should be representative of the total population and the information on the parameters likewise representative. Although more data could be obtained by investigating more incidents, it is not likely that the additional information collected would approximate risks more closely than the sample.

Risk of death

In the 64 events involving the evacuation of 1,142,336 persons, there were ten deaths reported attributed to the evacuation process. The incidents and circumstances under which the deaths occurred follow:

1. Hurricane Camille, Gulfport, Mississippi, August 1969. Ten thousand persons were evacuated from a fifteen-square-mile area in Harrison County, Mississippi, during the hurricane. One person had a heart attack during the evacuation process and died in a shelter.

Table 2

Meteorological Conditions During Evacuation

Condition	Number of Events
Rain	26
Clear	20
Cloudy	7
Fog	1
Snow	5
No Data	5
Total:	64

Table 3

Time of Day During Which Evacuation Took Place

Time	Number of Events
Day	27
Night	22
Day and Night	11
No Data	4
Total:	64

Table 4

Conditions of Roads During Evacuation

Condition	Number of Events
Wet	30
Dry	21
Ice	1
Varied (Wet and Dry)	2
No Data (Includes Boat Evacuation)	10
Total:	64

Table 5

Size of Population Evacuated and Number of Events

Size of Population Evacuated	Number of Events
5 - 99	18
100 - 999	16
1,000 - 9,999	17
10,000 - 99,999	9
100,000	3
No Data	1
Total:	64

2. Collapse of the Baldwin Hills Reservoir, Los Angeles, California, December 14, 1963. An earthen dam collapsed and inundated an area of 10x13 city blocks. Of the 8,500 persons evacuated, two were drowned in the process. It was emphasized, by the individual who completed the questionnaire, that "The deaths occurred because, for some unknown reason, the persons did not follow evacuation directions and drove the wrong way into deep water."

3. Flood, Humbolt County, California, December 22, 1964. In a flood postulated to occur once in 100 years, 200,000 persons, over an area of 450 square miles, were affected under adverse weather conditions. One hundred and eighty-three of the persons were airlifted by helicopter to safer places. In the process, one helicopter crashed killing seven persons. Two other helicopters were lost without loss of life.

Risk of injury

There were only two injuries reported in the evacuation of 1,142,336 persons:

1. Flood, Ferndale, Washington, January 8, 1971. Approximately 200 persons were evacuated from an Indian Reservation due to a flood which eventually covered 30 square miles. One broken arm was reported as a result of an accident incurred during the evacuation.

2. Tidal Wave, Cannon Beach, Oregon, March 28, 1964. Thirty-one hundred persons were evacuated in one and one-half hours after a three-minute warning of a tidal wave which flooded an area of 3.5 square miles. One accident (a heart attack) was attributed to the evacuation.

Cost of evacuation

No information concerning the complete cost of an evacuation was obtained from either personal contacts made during the study or data collected during the individual investigations of the 54 incidents.

Fragmentary cost figures were collected from a few different organizations for their activities related to different specific events. These could only be useful for making estimations of total incident costs, and had no significance, viewed alone, for evacuation costs.

A number of reasons are suggested for the paucity of information:

1. There is not a centralized group--Federal, state, or local--which collects information about evacuation costs, and there is not a centralized group which is concerned with the total cost of a disaster or emergency situation.

2. Although, in a major disaster situation, a total dollar value may be placed on the economic effect of the incident, this figure may or may not be a reasonably true estimate of the real impact, and generally does not include all the cost incurred. This value usually includes property damage, agricultural losses, business and industrial losses, clean-up costs, cost of temporary housing, and other major financial aid.

3. Even in the incidents which have a total dollar value attributed to them, the cost for the evacaution--moving people out, providing for them while they are away from home, and getting them back--is not identifiable as a separate item.

4. In an incident of sufficient magnitude which requires much manpower and equipment from many different organizations, both governmental and private, and in which the participating groups keep records of their costs, the cost for the evacuation alone is not a separate, identifiable number. Another complicating factor is that not only is the total number of people not generally known but, at any one time, the number fluctuates. To further complicate the attempts to ascertain these costs: a) many people are volunteers who receive no compensation for their efforts, and b) others such as policemen, firemen, and civil defense personnel would be paid regardless of whether they participated or not.

Estimation of costs

The total cost of an evacuation could not be obtained from the surveys that were made, from existing literature, or from private conversations with people representing a number of different organizations. Estimates of the cost of evacuation would have to be made based upon a combination of: 1) costs incurred during an evacuation, whenever applicable figures exist, and 2) synthesized values based on certain assumed conditions.

Utilizing derived costs based upon the latter figures to estimate future evacuation costs is less exact and subject to a larger degree of error than estimating and projecting costs based upon real numbers from actual events; however, judicious use of the data should allow a reasonable estimate of the cost of an evacuation.

DISCUSSION OF RESULTS

The purpose of the study was to determine the risk of evacuating people, in terms of deaths, injuries, and costs, and any relationship between these risks and the parameters of the evacuation. If the risks attributed to the evacuation process are greater than the risk from a specified radiation exposure, then other countermeasures are advised or guidelines for radiation exposure are set for a more favorable radiation risk/evacuation risk ratio. Likewise, if relationships could be demonstrated between risk of death, injury, or cost and any parameters of the evacuation, particularly increasing evacuation population size, they might have an influence on the selection of radiation guides for evacuation.

The parameters thought to have an effect on evacuation risks and which formed the basic questionnaire (appendix A) that was developed include:

1. Disaster agent (flood, fire, earthquake, etc.)
2. Number of persons evacuated
3. Size of area evacuated
4. Type of area evacuated (rural, urban, suburban, etc.)
5. How evacuated (private vehicle, boat, bus, etc.)
6. Types of roads (rural, expressway, etc.)
7. Average length of evacuation route
8. Weather conditions at time of evacuation
9. Road conditions during evacuation
10. Evacuation plans available and, if so, used
11. Time between evacuation and onset of incident
12. Time required to evacuate
13. Time people were in an evacuated status

Risk of death

Ten deaths attributed to the evacuation process were reported by the responders to the 64 questionnaires completed on the 54 incidents utilized in the study. These incidents involved the evacuation of 1,142,336 people under a wide variety of environmental conditions. Seven of the deaths were due to a helicopter crash; two drowned in an automobile; and one death was due to a heart attack. The deaths occurred in three separate incidents caused by floods involving 183, 8,500, and 10,000 persons evacuated, respectively.

Because of the low number of deaths reported (ten), it was not possible to make valid conclusions which could be used as a basis for predicting the risk of death. The low number of deaths also does not allow comparison of the evacuation parameters and their effect on the risk of death. Furthermore, a valid statistical analysis is precluded.

In collecting information relative to the study, it was frequently expressed, either in published reports(16,17) or in the personal opinions of people interviewed, "that there were no deaths or injuries and the accident rate was lower than normal." It was also the opinion of those interviewed, who have been involved in evacuations, that they expected deaths, injuries, and/or accidents to be "lower than normal." However, a definition of normal was not given.

To define normal risks and to compare deaths reported from evacuations to this norm, a number of data sources were reviewed and analyzed. Relevant data was used to allow comparisons to be made. It is emphasized that, because of the low number of observations (ten deaths) reported in the study, no valid statistical comparisons can be made or conclusions derived.

Deaths from motor vehicle accidents

Since most of the evacuees (more than 99 percent) in the study were evacuated by motor vehicles, a comparison was made between the motor vehicle death rate observed in the study and the National Motor Vehicle Death Rate (27). Although there is a question as to whether or not the deaths reported (two persons in an automobile did not follow the evacuation directions and were drowned in high waters) are deaths due to vehicle accidents, it was arbitrarily decided that they would be classified as such.

Based on the numerical comparison from table 10, the risk of death per person-mile would be four times higher during an evacuation than the death rate during normal driving conditions.

Table 6

Comparison of National Motor Vehicle Death Rate and Study Death Rate

	National[a]	Study
Vehicle-Miles	1.17×10^{12}	N.A.
Registered Vehicles	1.15×10^{8}	N.A.
Persons/Vehicle	1.9	N.A.
Persons at Risk	2.2×10^{8}	5.2×10^{5}
Person-Miles	2.22×10^{12}	2.24×10^{7}[b]
Miles/Person-Day	27	43[c]
Deaths	5.47×10^{4}	2
Deaths/Person-Mile	2.4×10^{-8}	8.9×10^{-8}

Notes:

a -- Accident Facts, National Safety Council, 1972.

b -- Computed from evacuation mileage times population evacuated for each evacuation incident.

c -- Computed based on assumption that evacuation travel occurs over 24-hour interval.

N.A. -- Not available.

Table 7

National and Study Motor Vehicle Death Rates (Per Day)

	National[a]	Study[b]
Persons at Risk	N.A.	5.2×10^5
Deaths	N.A.	2
Daily Death Rate/ 100,000	.07	.39

Notes:

These numbers can be compared since the average miles traveled per day is about the same in both cases.

a -- Statistical Abstract of the United States, 1972. (Based on 1970 data.)

b -- Assumes average time at risk is one day.

N.A. -- Not available.

Table 8

National and Study Daily Death Rates from all Accidents

	National[a]	Study
Persons at Risk	N.A.	1.13×10^6
Deaths	N.A.	10
Daily Death Rate/ 100,000	.15	.90

Notes:

a -- Statistical Abstract of the United States, 1972. (Based on 1970 data.)

N.A. -- Not available

Deaths from all accidents

Since all causes of death attributed to accidents incurred during the evacuation were considered, a comparison was made between the daily death rate from all accidents in the United States and the daily death rate per 100,000 persons in the evacuation.

From tables 11 and 12, the rates for evacuation-caused accidents are three and six times higher than the national figures.

Deaths from major cardiovascular diseases

One death was reported from a heart attack which occurred during an evacuation. From major cardiovascular diseases, 494 deaths occur per 100,000 persons a year (19). The study shows one death per 381 persons a year and scales up to 262 deaths per 100,000 persons a year, approximately half that expected.

Deaths involving helicopters

No comparisons were made between deaths caused by a helicopter crash as reported in the study and national helicopter crash statistics. The probability of an evacuation by helicopter is so unlikely as to make any predictions or comparisons invalid.

Estimating the risk of death

A chi square test (appendix H) was made on the data presented in table 10. Although the results of the test show that a real difference exists between the national average death rate and that of the evacuees, the small numbers of deaths (two) observed in the study does not permit a valid application of the chi square test.

In order to provide an estimate of the deaths which may occur because of an evacuation and until substantial evidence proves otherwise, it would appear a reasonable predictive value would be the National Motor Vehicle Accident Death Rate. This is 2.4×10^{-8} deaths per person-mile or .07 deaths per day per 100,000 persons.

Although no statistically valid comparison or test can be made to confirm these values, there is some subjective evidence, based on opinions and reports received, that the use of the National Motor Vehicle Accident Death Rate to estimate the risk of death in an evacuation permits a reasonable approximation of the risk. Furthermore, there does not seem to be any activity with a risk of death, other than motor vehicle transportation, that can be more closely related.

Other justifications for basing risk estimations on the National Motor Vehicle Accident Death Rate follow:

1. Since more than 99 percent of the movement of people in an evacuation is by motor vehicle, the probability is great that accidents could occur involving vehicles.

2. Accident rates at home or work are not comparable to situations encountered away from home at motels or reception centers.

3. A state of "panic" does not exist during an evacuation which would result in reckless and high-speed driving (18). The evacuations were very orderly and vehicle traffic tends to move at relatively low speeds (35 mph is the average). Nationally, 74 percent of traffic accident fatalities occur at speeds greater than 40 mph (18). At least 50 percent of the National Motor Vehicle fatalities have been attributed to drinking (18), whereas drunk-driving has not been observed in evacuations (17). From published reports(16,20) and observations of personnel familiar with evacuation, traffic moves at a much slower rate, and cannot even be compared to commuter traffic leaving a city. The slowdown is caused both by the fact that there is more traffic on the highways and feeder routes and that more personnel are involved in traffic control.

4. The daily death rate per 100,000 persons from all accidents (0.15) is about two times higher than the daily death rate per 100,000 persons from motor vehicle accidents (0.07). All accidents include many situations such as poisoning, railroad deaths, industrial accidents, etc., which would be dissimilar to circumstances in an evacuation. The dissimilarities of conditions of death rate calculated for all accidents with evacuation conditions seem to justify using the lower motor vehicle death rate for predictions of evacuation death risk. However, with the other uncertainties that exist, a factor of two higher in the predictions would not be unreasonable.

Risk of injury

Only two injuries requiring medical attention were reported in the study. One heart attack (the victim recovered) and one broken arm were attributed to the evacuation.

Since only two injuries were reported in the survey of 1,142,336 persons who were evacuated, it was not possible to demonstrate any relationship between injury and evacaution parameters.

Assuming the broken arm occurred in an automobile accident (the responder to the questionnaire could not remember how it happened), a comparison is made in table 13.

The figures that are given in tables 13, 14, and 15, and the comparisons that can be made between national figures and non-fatal accident rates and the rates obtained based on data collected in the study, are useful only for a perspective or relative view. No valid statistical comparison or correlation can be made between the two sets of data since the number of observations, one (the heart attack is not included), from the study is well below the number of observations necessary for valid statistical analysis.

For purposes of estimating non-fatal injuries which might occur during an evacuation, it would appear appropriate to use the United States rates for injuries due to motor vehicle accidents of 9.0×10^{-7} injuries per person-mile, or 2.7 per 100,000 persons per day.

Although non-fatal accident rates from causes other than motor vehicle accidents could be used to predict evacuation risks, a larger error might be introduced in the predictions. This error could be due to comparing values obtained under a particular set of circumstances to a situation where the conditions are dissimilar. Utilizing the total accident rate, which includes accidents occurring at home, work, in motor vehicles, and in miscellaneous situations, or using home or work accident rates alone does not approximate evacuation conditions as closely as motor vehicle rates.

Reliability of data

The question arises as to how reliable the figures for deaths (ten) and injuries (two) reported in the study are. Do they accurately reflect the true number of the deaths and

Table 9

Comparison of National Motor Vehicle Injury Rate and Study

	National[a]	Study
Vehicle-Miles	1.17×10^{12}	N.A.
Persons Per Vehicle-Mile	1.9	N.A.
Person-Miles	2.22×10^{12}	2.28×10^{7}[b]
Injuries[c]	2.0×10^{6}	1
Injuries Per Person-Mile	9.0×10^{-7}	4.4×10^{-8}
Injuries Per Day Per 100,000 Persons	2.7	0.09

Notes:

a -- Accident Facts, National Safety Council, 1972.

b -- Computed.

c -- An injury which prevents a person from performing any of his usual activities for a full day beyond the day of the accident.

N.A. -- Not applicable.

Table 10

National Health Survey 1968-70 Average Non-Fatal Injuries[a]

Total Injuries[b] Requiring Medical Attention Per Year	51,229,000
Injury Rate Per Day Per 100,000 Persons	69
Motor Vehicle Injuries Requiring Medical Attention Per Year	3,551,000
Injury Rate Per Day Per 100,000 Persons	4.8
Injuries Other Than Motor Vehicle Requiring Medical Attention Per Year	47,678,000
Injury Rate Per Day Per 100,000 Persons	64.2

Notes:

a -- Accident Facts, National Safety Council, 1972.

b -- NHS definition of injury: Medical attention injuries include bed disabling injuried (confining a person to bed for more than half of the daylight hours on the day of the accident or the following day), restricted activity injuries (causing a person to cut down on his usual activities for a whole day), and non-restrictive but medically attended injuries.

Table 11

National Safety Council -- 1971 Disabling Injuries[a]

All Accidents Per Year	11,200,000
Disabling Injury Rate[b] Daily Per 100,000	15
Motor Vehicle Accidents Per Year	2,000,000
Disabling Injury Rate Daily Per 100,000	2.7
Accidents Other Than Motor Vehicle Per Year	9,200,000
Disabling Injury Rate Daily Per 100,000	12.3

Notes:

a -- Accident Facts, National Safety Council, 1972.

b -- National Safety Council definition of injury: a disabling injury is defined in the American Standard Z16.1 as an injury which prevents a person from performing any of his usual activities for a full day beyond the day of an accident. The American Standard applies to work injuries, but the Council had adapted this definition to injuries in other categories.

injuries that occurred in the events investigated? Most of the questionnaires were completed by persons on a local level who were intimately involved with the particular incidents and their recall of the events was generally very good. Some documentation of the deaths and injuries associated with an evacuation has occurred. These have been reported in "Carla" involving the largest evacuation studied (500,000 persons) (16). Verbal confirmation that no injuries or deaths have resulted from evacuations in one state has been obtained (21). This can be further confirmed because no compensation claims (permissible under law) have been filed to this effect (21).

Deaths

It seems reasonable to conclude that the number of deaths is a fairly accurate number. In most of the incidents investigated, the number of evacuees was less than a few thousand. Because of the relatively small number of people involved, a few deaths would attract sufficient attention, so that the cause of death would be ascertained, recorded, and the results reported. This may not be as true in a large disaster where hundreds of people are killed. That is, in these situations, whether the person died because of something that occurred during the evacuation or for some reason initiated by the disaster probably has less certainty. However, the numbers of these types of disasters are small. Other events which were investigated during the study, although involving the evacuation of a relatively large number of people, had few or no deaths due to the disaster agent. In these situations, again, one or two deaths would stand out.

The general conclusion is that the number of deaths reported during the study is reasonably accurate. It is unrealistic to believe that the reported ten deaths could be low by a significant factor.

Injuries

Although the number of deaths reported appears to be a reasonably accurate reflection of the true number, the reported number of injuries (two) attributed to the evacuation process seems low. This conclusion is based only upon reasonable doubt and cannot be substantiated. The definition of an injury used in the study was an injury serious enough to require medical attention. Even though it is believed that the nonfatal injuries due to vehicle accidents witnessed in the study is lower than normal, it seems logical to assume that other types of injuries do occur that may not have if the people were not evacuated. This is not to imply this rate is higher or lower than normal, but the study data (two injuries) probably has a higher degree of inaccuracy than the death rate.

It is thought that the lack of credibility is not due to the numbers reported by the responders, but that there is no reporting system for injuries comparable to the registry for death. There is not a reliable, established mechanism for collecting injury statistics, unless they are traffic-connected or needed for legal liability. Consequently, unless occurring in significant number and degree, they may be overlooked.

Comparison of predicted and observed risk of injury and death

As an example of an estimation of prediction of death and injury during an evacuation, based on the application of the National Highway Statistics, Hurricane Carla was chosen. This evacuation was not included in the estimate of risk (tables 10, 11, and 13) because the number of persons involved, the average number of miles evacuated, and other details were not known with the desired accuracy. It is used here as a disaster to which a projection of the risk of death and injury might be applied for certain assumptions and compared with actual results which did occur.

Hurricane Carla(16,22,23) affected the states of Texas and Louisiana from September 3 to 14, 1961, and caused the largest evacuation in American History. It was estimated that between 50,000 and 80,000 persons were evacuated in Louisiana and between 300,000 and 800,000, with the most reasonable estimate of 500,000, persons were evacuated in Texas.

The Head of the Texas Department of Public Safety called it "the wettest dry run in mass evacuation in the history of America " (16) In the movement in Texas there was not a single fatality attributable to the evacuation. There was not even a reported major accident (16).

Based upon data obtained from Hurricane Carla and the recommended death and injury prediction, table 16 was derived. As observed in table 16, using the National Motor Vehicle Accident Death and Injury Rate (tables 10 and 13), more deaths and injuries were predicted than observed in one incident only--Hurricane Carla.

If the same rationale were applied to the 63 other events investigated, in all but four, the results would be approximately the same as for Hurricane Carla. The predicted values

Table 12

Comparison of Predicted and Observed Deaths and Injuries in Hurricane Carla

	Predicted	Observed
Number of Deaths Per Person-Miles[a]	1.20	0
Number of Deaths Per Day Per 100,000 Persons[b]	0.35	0
Number of Injuries Per Person-Miles	45.0	0
Number of Injuries Per Day Per 100,000 Persons	13.5	0

Notes:

a -- Distances traveled in the evacuation, one way, varied anywhere from a few miles to 350 miles; an assumed 100 miles per person is used in the above calculations. Person-miles is the product of the number of people evacuated (500,000) times the average distance evacuated/person (100).

b -- Assumes evacuation to and from is no longer than one day.

would be higher than the observed values when the 1) population or 2) person-miles evacuated is large enough to project whole numbers of deaths and would approximate zero when the population or person-miles is small.

In the three incidents where deaths were reported and the two incidents where two injuries were reported, the projected deaths or injuries would be zero.

Based on the foregoing, the following is concluded:

1. For a specific incident, when the population times the miles evacuated is large, predicting risk using the National Motor Vehicle Accident Death and Injury Rates may lead to an overestimation of expected injuries and deaths.

2. When the incident population evacuated or the person-miles traveled is small, using the National Motor Vehicle Accident Death and Injury Rates would produce fractional values which would not be observable.

3. The projected value of 1.20 deaths does not imply that at least one death would be expected. The projected one death is due to the determination of person-miles based on a widely divergent estimate of persons evacuated and miles traveled. In other words, the standard deviation is not known and cannot be determined.

4. The projected number of injuries, while having no known standard deviation, is large enough to allow implication that fewer injuries were observed than would have been expected. This was presumably due to the low vehicle velocity and greater traffic control.

5. In most cases, the observed values may be lower than calculated and, in a few cases (four out of sixty-four events in the study), unpredictable deaths and/or injuries may occur. It would appear, based on this study, the probability is low that the actual number of deaths or injuries occurring in a specific event would be higher than that predicted using the National Motor Vehicle Accident Death and Injury Rate.

6. Projections of deaths and injuries are not statistically valid for population sizes likely to be encountered in single evacuation events. Only for several evacuations involving perhaps tens of millions of persons would death risk projections be reasonable.

Approximating evacuation costs

The total dollar outlay which results from an evacuation is a combination of: 1) costs, defined here as the money involved in the movement and care of people, and the security of the evacuation area, and 2) the financial losses, which are the monies lost because people are removed from the area; consequently, income is lost and the economy of the area is affected. Costs are primarily determined by the number of evacuees, distances traveled, length of time of the evacuation, etc., whereas financial losses are a reflection of the economics of the area (farm, industry, manufacturing, etc.).

For ease in determining evacuation costs, four categories for estimations of costs were used: 1) costs involving evacuees, 2) costs involving evacuators, 3) financial losses of farm areas, and 4) financial losses of urban and industrial areas.

Cost to evacuees

The costs of an evacuation which are related directly to the people who are being evacuated are: 1) expenses involved in providing shelter, food, and the other necessities for health and welfare, and 2) the financial losses the evacuees may incur if their income sources are closed down or access is not available to them, or if their property is affected by disuse.

A most important consideration in any evacuation is not only to remove the people safely from the area but to provide for their food and shelter needs elsewhere. The cost of providing these basic requirements are initially borne by the people themselves, by governmental or volunteer organizations, or by a combination thereof. Ultimately, these costs might be repaid by others, such as insurance companies or those who have been shown to be liable.

Costs were obtained for food and housing based on two situations. First, that food and housing were made available on a mass shelter basis. Second, that evacuees would utilize motels, hotels, and restaurants, if they were available.

The major cost to the evacuees is the financial loss incurred if conditions are such that the person is in an evacuated status for a long enough period of time that property is affected and loss of income results, or if the contaminating incident is of a magnitude which affects either of these two factors.

Table 13

Estimates of Costs of Food, Shelter, and Transportation for Evacuees[a]

	Cost/Person/Day		
	Minimum	Average	Maximum
Commercial			
Food	$ 1.00[b]	$ 3.00	$ 7.00
Housing[c]	4.00	8.00	10.00
Food & Housing[d]	5.00	11.00	17.00
Transportation[e]	.85	1.00	1.20
Mass Care			
Food	$ 1.00	$ 1.75	$ 2.50
Housing	--	--	--
Food & Housing	.20 to .70[f]	5.00	--
Transportation[g]	.40	--	.55

Notes:

a -- References 9-15.

b -- Assumes food is self-prepared.

c -- Assumes two or more per room.

d -- Sum of Food and Housing.

e -- Privately-owned vehicle; assumes average round trip of 30 miles; three or four passengers per vehicle; 12¢/mile operating costs.

f -- Based on mass shelter/feeding during hurricanes; also includes personnel management costs.

g -- Based on mass transportation costs of 65¢ to 80¢ per mile for 45-50 persons per vehicle; average distance equals 30 miles.

Based upon the Statistical Abstract of the United States for 1972,(19) the per capita personal income in the United States for 1971 was $4,138. The median money income of all families for 1971 was $10,300. Utilizing these figures, loss of wages can be computed per day per evacuee.

The other major financial loss would occur when conditions were such that property (housing) and personal belongings were affected. The gross private domestic investment in residential structures in 1970 was $10,241 per capita (19). Hosehold equipment and furniture is valued at $5,000 per family (24). These figures would be used to calculate losses if long-term evacuations occurred.

Cost to evacuators

Costs incurred by organizations, private and governmental, assisting with an evacuation fall into four generalized categories: 1) salaries and wages of the personnel involved, 2) transportation costs, both for their own personnel and transportation provided for evacuees, 3) food and lodging costs for their own personnel and evacuees, and 4) costs for special equipment and supplies such as radios, helicopters, boats, etc.

Within any of the categories, not only do costs vary according to the circumstances of the evacuation situation, but by the fact that voluntary contribution of help in the form of personnel, food, shelter, clothing, and equipment is generally available. Although this is free for the event, ultimately someone pays for it. No attempt is made to place a dollar value on this free service.

Salaries and wages

Since National Guardsmen are frequently used in disaster situations, several incidents involving National Guard activities were reviewed to determine the average cost per man-day for the guardsmen (25). Analysis of the incident indicates that the cost per man-day is $28, corrected to the present day pay scale.

Average policemen and firemen cost per man-day was determined to be approximately $36 for each group (19).

Based upon the median family income in 1971 of $10,300(19) and assuming it is earned by one individual, this would amount to about $40 per man-day.

It appears reasonable for a first-cost figure to use an average of the above values of $35 per man-day to estimate evacuators' cost.

Transportation, food, and shelter would be the same as shown under Cost to evacuees.

Information derived from references and private communications was used to estimate the number of persons required to evacuate and secure the affected area as a function of the number of evacuees (16,26-31). The values ranged from 0.4 percent to 5 percent of the number of evacuees with an average value of 2 percent.

Farm area evacuations

The evacuation of people from a land area used predominantly or partially for agriculture presents complex problems and incurred costs. In general, the major cost is the monetary loss which would be suffered because of the non-availability of the marketable products and, on a long-term basis, the removal of the land from farm use. Not only does this result in the direct loss of income to the producer, but, depending on how many farms are involved, it could have an extensive impact on the overall economy of the area.

There are a great many factors which affect the cost of a rural evacuation. The factors which would have major impact on costs would be:

1. The type(s) of farm(s) in the area
2. The size of farms
3. Income realized from sale of product(s)
4. The number of farms
5. The values of farm land, equipment, property, etc.
6. The length of time of the evacuation
7. The time of year the evacuation occurs

Widespread variation and ranges, within the first five items exist, not only between regions within the United States, but within the regions or even narrower geographic boundaries. Superimposed on these variations are the two conditions imposed by the initiating incident: 1) the length of time people are in evacuation status, and 2) the time of year that it occurs. Crop losses would occur if the evacuation status is imposed over a long time or in short-term evacuations if they occurred at critical time during the year.

Assuming no decontamination was eventually needed, the greatest loss of income would occur when the land could not be used for an extended period of time. This would probably occur primarily when evacuation status is long.

However, if the evacuation time is relatively short (a few days to a few weeks), then the financial loss would, to a large degree, depend on the time of year. This would relate to the harvesting or planting periods of crops. For dairy farms or farms used principally for poultry or livestock production, the season of the year is not as important. Here, the main loss would be caused by the absence of personnel if a complete evacuation was effected; consequently, no one would remain to take care of the stock and a permanent loss of stock could occur.

The direct costs attributed to evacuating farms are dependent upon the exact nature of the particular situation. Costs are so variable, depending on the circumstances, that it is unrealistic and virtually impossible to assign costs for all the permutations that might exist for one farm, let alone the combinations which would exist for two or more farms. Additionally, as the number of farms in an area increases, then the total economy of the area becomes more directly dependent upon the farm income and more affected by agricultural losses. Not only is the immediate geographic area affected, but this can, because of intricate marketing and area interdependence, have an impact on areas far removed.

Regardless of other factors, the major determinant of the cost range--from minimum to maximum--for an evacuation is the length of time of the evacuation, assuming a complete evacuation. It is obvious that livestock or poultry could be left unattended for only a few days, whereas predominantly crop farms could be left for longer periods of time depending on the season.

If the conditions were such that: 1) the length of time of an evacuation was 48 hours or less for a farm with livestock, or 2) longer in the case of a farm with no livestock, but occurring in a non-critical period in the crop cycle, then the cost of the evacuation would be primarily the cost of housing, food, and transportation for the evacuees and costs incurred by the evacuators.

It is not realistic to base the costs of the evacuation on the worst possible situation--which would indicate a catastrophic initiating event--although this would, in fact, establish an upper limit for a particular area (24). Rather, it seems more logical to establish, as an average evacuation cost for a farm, only the additional cost of the loss of income based on the value of the farm product on a yearly basis.

Based on table 7, to estimate the cost of evacuating a farm, assuming a complete loss of income, the average United States values of products sold per farm ($17,000) should be used. This assumes that the contaminating event is not of sufficient magnitude to affect the value of land, buildings, and equipment which, based on the United States average, would add about $87,000 (19) ($76,000 for land and buildings; $12,000 for farm implements and machinery). The $17,000 estimate also does not include replacement cost of livestock or poultry. Livestock replacement could add considerably more to farm costs.

Urban area evacuations

Since the economy of an area is based upon receiving money for goods produced or services rendered and the subsequent use of the money (income), the major cost or potential cost of an evacuation is the financial losses incurred when the work force is not available. For other than a short-term evacuation, the disruption in productivity results in a loss of wages for the people employed by the activity affected. The inability of the activity to deliver goods and services thereby affects their financial balance.

In addition to the loss of income caused by the lack of productivity, there are other attributable costs such as, the closing down processes, losses of inventory and vital equipment, and activities which require personal attention.

Not only would the closing of businesses, industry, manufacturing, etc., affect the economics of the particular area evacuated, but it would cause an adverse financial impact on other areas which are dependent as suppliers or purchasers such that, depending on the circumstances, a mushrooming effect occurs.

Table 14

Farm Information in the United States (19)

Area	Number of Farms x(1000)	Average Acreage Per Farm	Average* Value Per Farm (Dol.)	Value of Farm Products Sold (Mil. Dol.)	Average Value of Farm Products Sold Per Farm (Dol.)	Percent of Farms With Sales of $10,000 or More
US	2730	390	76000	45609	16700	35
NE	29	196	62000	683	23550	47
MA	123	163	59000	2138	17380	42
ENC	513	184	71000	7544	14700	40
WNC	639	437	77000	12553	19640	50
SA	371	184	55000	4874	13140	24
ESC	392	155	37000	2749	7010	14
WSC	399	511	37000	5731	14360	25
Mt	120	2139	87000	3839	31990	47
Pac	145	516	166000	5498	37920	40

*Value of land and buildings.

Table 15

United States by Regions and States in Region

New England (NE)

- Maine
- New Hampshire
- Vermont
- Massachusetts
- Rhode Island
- Connecticut

Middle Atlantic (MA)

- New York
- New Jersey
- Pennsylvania

East North Central (ENC)

- Ohio
- Indiana
- Illinois
- Michigan
- Wisconsin

West North Central (WNC)

- Minnesota
- Iowa
- Missouri
- North Dakota
- South Dakota
- Nebraska
- Kansas

West South Central (WSC)

- Arkansas
- Louisiana
- Oklahoma
- Texas

South Atlantic (SA)

- Delaware
- Maryland
- Virginia
- West Virginia
- North Carolina
- South Carolina
- Georgia
- Florida

East South Central (ESC)

- Kentucky
- Tennessee
- Alabama
- Mississippi

Mountain (Mt)

- Montana
- Idaho
- Wyoming
- Colorado
- New Mexico
- Arizona
- Utah
- Nevada

Pacific (Pac)

- Washington
- Oregon
- California
- Alaska
- Hawaii

The problem of determining the cost or financial losses which would accrue to the industrial, manufacturing, business, and service community on a national basis due to an evacuation is very complex. Given the tremendous range of variables directly related to the production of goods and services and their impact on each other and the community, superimpose the variables connected with the circumstances of the evacuation, an infinite number of cost possibilities can be derived. The nearness of any particular cost derived to the true costs would be dependent upon the similarity of assumptions used to derive the postulated costs and the conditions of the real situation.

Another approach would be to use, as a first approximation of cost, average values of costs or losses which could be applied across the Nation. Although average values may also have a large degree of error when applied under a specific set of circumstances, it does not seem that this error warrants a more critical approach unless the specifics for a certain geographic area are needed.

It would appear that the most meaningful indicator of the productive values of an area would be the gross productive value of the area per capita. Scaled to the national level, this would be the Gross National Product (GNP) per capita.

The Gross National Product is the total national output of goods and services valued at market prices (19). Estimates of local goods and services produced by business and industry located in potential impact areas may be determined by using the methods of computing the GNP.

The product of the GNP per capita, the number of people evacuated, and the length of time of the evacuation in years or fraction thereof would give an estimate of the cost in terms of financial losses in goods or services in the area. Implied in the above estimate is that these revenue-producing sources closed down due to the evacuation of the personnel necessary to operate them.

In utilizing the GNP per capita as an estimate of part of the total cost of an evacuation, the loss of wages or salary to the evacuee should not be included because the GNP per capita includes wages and salaries. Also, farm income would not be listed separately as using the GNP would reflect these losses.

Based on the 1970 data (19), the Gross National Product per capita was $4,670.

Table 16

Values to Use for Evacuation Cost Estimates

1. **Evacuee Cost**	
Food and Housing	
Commercial (Private)	$11/Person/Day
Mass Care	$5/Person/Day
Transportation	
Private	$1/Person/Day
Commercial	55¢/Person/Day
Loss of Income (if applicable)	$4,200/Person/Year (or appropriate yearly fraction)
Loss of Structures	$10,241/Person/Year
Loss of Personal Property	$400/Person/Year
2. **Evacuator Cost**	
Ancillary Personnel*	$35/Person/Day
Food, Housing, Transportation	Same as Evacuee Cost
*Number of personnel needed 2% of population evacuated	
3. **Farm Area Evacuations**	
Loss of Farm Products	$17,000/Farm
4. **Urban Area Evacuations**[a]	
Value of Products or Services Lost	$4,700/Person/Year[b] (or appropriate yearly fraction)

a--If farm losses are computed as a separate item, deduct $200 from yearly GNP/capita.

b--When using this figure (GNP/capita), loss of income should not be included as a separate item.

Accuracy of estimating cost

Dollar values have been derived based on information collected during the study and on existing published information which could be used as a first approximation of evacuation costs. In any specific aspect of the evacuation which incurs a cost, the variation can be so great as to invalidate any projected number. Given the many aspects which affect cost and financial losses, each with its own set of variables, a wide range of costs can be postulated.

It is not possible or practical to attempt, on a nationwide basis, to do a complete cost analysis for all aspects of an evacuation. Even if all the data could be collected on a specific past event, its applicability to a future event may be marginal. Thus, it seems more reasonable for purposes of cost assessment on a national basis to use those values which account for the greater cost as a first estimation of risk.

More accurate estimates of the cost/financial losses incurred in an evacuation, under a given set of circumstances, can be obtained if the focus is narrowed to a more limited area. At a particular site, the various parameters which would affect cost can be ascertained with more exactness. Conditions can be varied which would affect the parameters and the costs postulated for the parameters, under the stipulated conditions, with a higher degree of accuracy.

Parameters to be determined

- Area
    - Size of area affected
    - Location of area affected
- Population
    - Number
    - Distribution
    - Makeup
- Institutions (hospitals, jails, colleges, nursing homes, etc.)
    - Type
    - Population
    - Care required

Farms

- Size
- Type
- Product values

Business and industry

- Type
- Size
- Work force
- Product value

Evacuation

- Mode(s)
- Number of evacuators required
- Shelters needed
- Security of affected area
- Duration of evacuation

By obtaining information for these and other pertinent parameters, various simulated accident situations can be modeled and costs obtained for the evacuation for the specified conditions. On a national basis, this same approach is valid but more assumptions are necessary, thereby making the results less accurate.

It was specifically pointed out by both the responders to the questionnaires and in personal discussions with others responsible for disaster services at the state level, that the potential cost involved in an evacuation would not be a factor in the decision to advise an evacuation. These opinions were based on the fact that in their experiences with various types of disasters requiring an evacuation, it was obvious that to not remove people from the area would result in loss of life and many injuries. It is probably also true that the expenses involved in the evacuation were relatively small. Even in the worst modern disaster situation in terms of numbers of people involved and cost (Hurricane Agnes) (32), evacuation costs constituted a small percentage of the total cost of the storm.

Additionally, it was pointed out that the person usually responsible for ordering an evacuation is a political figure and the decision to evacuate is difficult to make, especially when the disaster agent is not obvious or imminent. It would appear that the cost of evacuation would be a minor consideration in the decision to call an evacuation, especially if there were any risk at all from the disaster agent.

OTHER ASPECTS OF EVACUATIONS

While collecting data pertinent to evaluating the risks of evacuation, other relevant information was accumulated, both from reports received and from discussions with many people concerning disasters, emergencies, and evacuations. Generally, these are various types of problems or situations that can have some effect on evacuations.

Time required to evacuate population groups

In the event of a nuclear incident, the population in the affected area may receive a dose commitment because evacuations require a finite time to accomplish. Ideally, it would be advantageous to be able to determine beforehand, the time required to evacuate a population group. Knowledge of the time will permit a comparison of the projected dose to the dose savings by evacuation.

Attempts were made in the study to collect data to ascertain what factors, if any, would have a significant influence on the time require to evacuate a population group from an area. Factors which were assumed to influence the time required for evacuation include: time lapse before onset of the incident, warning time, plans, time of day, weather conditions, population size, area size, area type (rural, urban, or suburban), population density, conditions of roads, and nature of the incident.

Data analysis and literature reviewed in the bibliography do not reveal any correlation between time of day, weather conditions, population size, area size, area type, road conditions, time lapse before onset of incident, use of plans, or the nature of the incident and the time required to evacuate a population group.

Warning time or the time required to notify the affected population was included in the time required for evacuation and no quantitative evaluation of this aspect can be made. However, some time element is required to warn the affected population to evacuate. Warnings have been issued through newspapers, television, radio, telephone, public address, and "door knocking." The method or combination of methods used for warning was dependent upon the nature of the incident and its time until onset. In slowly developing incidents such as floods and hurricanes, warnings were generally given through the news media. In potentially fast or fast-developing incidents, the news media was generally augmented by telephone, public address, and door knocking (16,27). Each potential impact area should be studied to determine an optimum warning system. New innovations such as computer telephoning, planes with loudspeakers, etc., should be explored (22,33).

A correlation was made between population density and the time required to evacuate the affected area (figure 1) from information received on questionnaires. The data are for private vehicles which were the predominant mode for evacuation (more than 99 percent). Evacuations were selected which involved urban, suburban, or rural areas only, and not mixtures. Population density ranged from approximately 15 persons per square mile to 20,000 persons per square mile.

The evacuation time ranged from approximately two to eighteen hours. Regression analysis up to a fourth degree polynomial provided the best curve fit and is indicated by the line through the data points (34). The line is described by the following equation: log (hours) = 1.30571 - 0.21243 log (persons/square miles) with a standard deviation of 1.5 hours and a correlation coefficient of -0.71.

The data indicates that more time is required for evacuation as population density decreases. Several reasons may be postulated for this:

1. The evacuation times reported in the questionnaire include the warning times as well as the time required to move the population out of the affected area. Warning times may lengthen as the population density decreases because of increasing distances between persons and more individual contacts may have to be made.

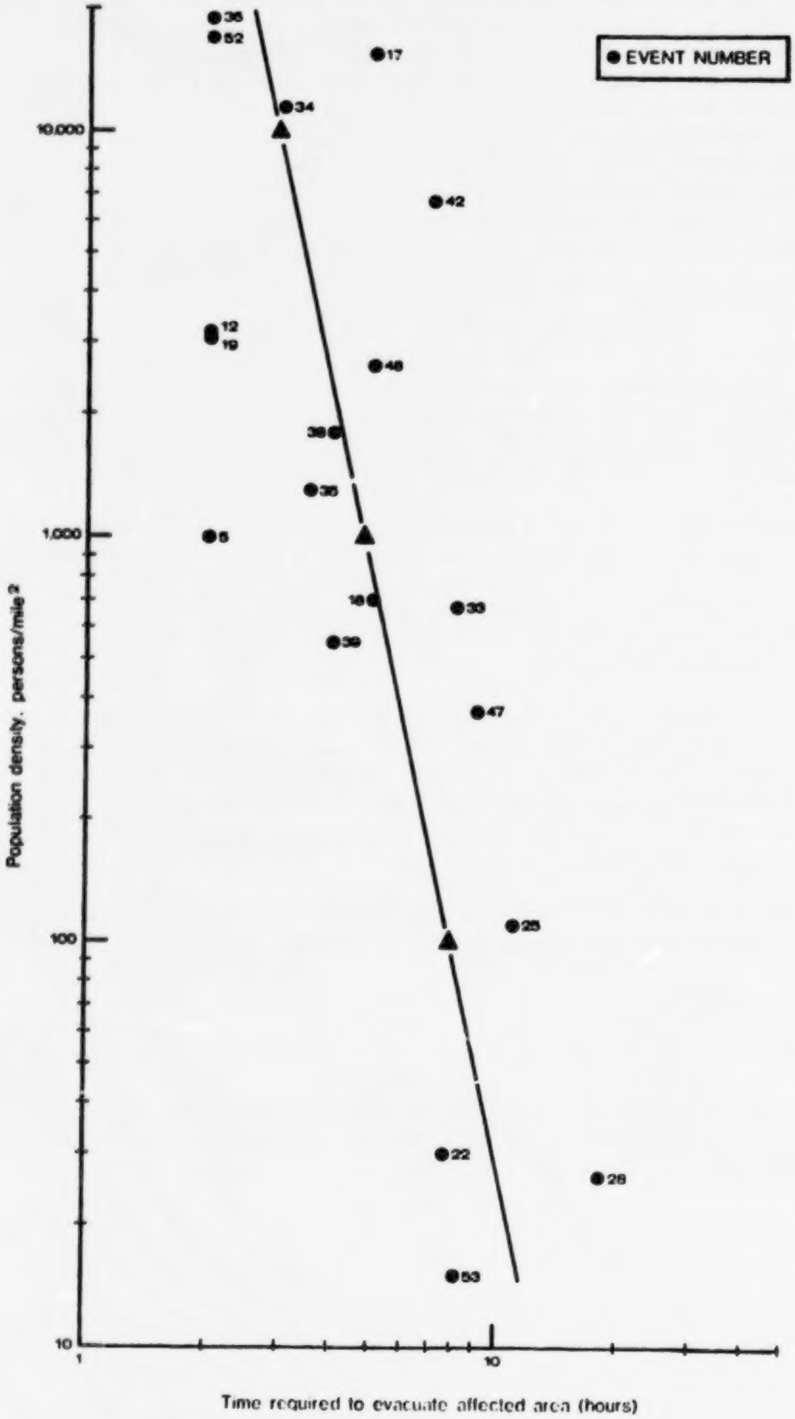
2. More time is required to prepare farms for a "shut down" than for residential dwellings.

3. Road networks generally decrease as the population density decreases; therefore, more time may be required for evacuation because of limited choice and direction of roads.

Some evacuation investigated occurred in high density urban and suburban areas approaching the population density of New York City and Los Angeles which have 26,000 and 6,000 persons per square mile, respectively (8). Two such cities,

Figure 1

Population Density vs. Evacuation Time



Baton Rouge, Louisiana (150,000 persons) and Wilkes-Barre, Pennsylvania (75,000 persons) were almost totally evacuated in two and five hours, respectively. The metropolitan business district of downtown Portland, Oregon, with a population of 101,000 persons and a population density of 25,200 persons per square mile, was evacuated in less than one hour during a Civil Defense test exercise (35). Although no correlation could be determined relating the total number of persons evacuated with evacuation time, two theoretical evacuation studies for large populations (more than 1,000,000 persons) show that such evacuations are possible within a reasonable time span. One study concluded that 4,300,000 persons could be evacuated from the Los Angeles Basin area in less than five hours (36). The other study, concerning the evacuation of approximatelty 2,200,000 children from the New York City metropolitan area, indicated that the evacuation could be accomplished in one to three days without disturbing normal weekday metropolitan activities (37). If the evacuation occurred on a Sunday, it could be accomplished during daylight hours.

A statistical comparison was made on the events used in figure 1 to determine if the use of a plan for an evacuation reduced the time required to evacuate the affected area. Based on the information collected, no significant difference between the evacuations utilizing a plan and those in which no plan was used could be determined.

An approximation can be made of the time required to evacuate affected areas based on the load capacity of roads. Several studies have been made on evacuation times related to road capacities (20,33,36,38). Estimates indicated that 1,000 vehicles could be moved per lane per hour (36). In observations during evacuations, 1,100 to 4,080 cars per lane per hour were observed (20,35,38). The average of actual observations was approximately 2,600 cars per lane per hour. The average vehicle occupancy observed during a large evacuation was four persons (35). Assuming 2,600 cars per lane per hour with an occupancy of four persons each, about 10,000 persons can be evacuated per lane per hour. Vehicle speeds observed ranged from 25 to 45 mph (with an average of 35 mph) during the evacuation (20,35,38). In addition to the time calculated, based on flow rate and vehicle occupancy, more time must be allowed for the warning period and for the average time required to drive out of the impact area.

Panic or hysteria associated with catastrophes

It appears that to the unknowing, a catastrophe often conjures a vision of mass confusion, panic, and a complete breakdown of private and public services. Normal processes are completely disrupted to a point that the functioning and interrelationships which exist between mankind, its society, and human values are disregarded and chaos exits. In this situation, people are unable to rationalize, follow directions, or relate to one another. The image, fostered by television, movies, and the press, is that people react to a calamity by panic and hysteria.

Numerous studies, both in other countries and in the United States (39,40), which have investigated the reactions of people in many types of emergency situations, have essentially dispelled the so-called "myths of panic." The Disaster Research Center of The Ohio State University, which is the only group in the United States now devoted solely to research on disasters and associated problems, had carried out 202 different field studies as of July 1972. These have included many investigations of peoples' reactions to various crises due to man-made or natural disasters.

In a recent publication entitled "Images of Disaster Behavior: Myths and Consequences " (40) the authors enumerate the following popular, but incorrect, images of disaster behavior:

1. People when faced with great threat or danger will panic. This takes the form of either wild flight or hysterical breakdowns. Even if the response is not intrinsically self destructive, it will generally involve giving little consideration to the welfare and safety of others. Persons cannot be depended upon to react intelligently and non-selfishly in situations of great personal danger.

2. Those who do not act irrationally are often immobilized by major emergencies. Thus, disaster impacts leave large numbers of persons dazed, shocked and unable to cope with the new realities of the situation, the longer run personal effects are rather severe emotional scars and mental health disturbances. Paralyzing shock is followed by numbing symptoms of personal trauma.

3. Partly because of widespread individual pathological reactions and partly because of the overwhelming damage to the resources of disaster-affected communities, the ability of local organizations to perform effectively in handling emergency tasks is severely limited. Not only do such organizations have to cope with the irrationality of others, but their own personnel are so immobilized by threat and damage that they cannot fulfill their necessary occupational tasks. Therefore, local organizations are ineffective agents to handle local emergency problems.

4. The social disorganization of the community which is a product of disaster impact provides the conditions for the surfacing of anti-social behavior. Since social control is weak or absent, deviant behavior emerges and the dazed victims in the disaster area become easy targets for looting and other forms of criminal activity. Crime rates rise and exploitative behavior spreads as Mr. Hyde takes over from Dr. Jekyll.

5. Community morale is very low in disaster stricken areas. Since impact localities are filled with irrational, disorganized and helpless persons and immobilized groups, the future of such communities appears bleak and problematical. Residents, even those not directly impacted, prepare to leave and there is a reluctance to reopen and rebuild shattered businesses and industries.

6. A descent into total personal and social chaos is possible in such stricken communities. Immediate and firm and unequivocal measures are necessary to prevent such a deterioration. But in general local and established community officials lack the resources and are so shaken by the disaster that they cannot take the drastic steps required.

The paper then explains why these "truths" prevail and the negative impact and implications they may have on policy and emergency planning.

The greater portion of the paper is devoted, based on the extensive work done by the Disaster Research Center, to demonstrate that these popular images are, in fact, myths and completely unrelated to actual fact. A generalization that can be made is that peoples' reactions and behavior under adverse, abnormal situations are diametrically contrary to popular myths.

Based on the Disaster Research Center report, "Images of Disaster Behavior," peoples' behavior during an emergency is characterized by:

1. The idea that people will panic in the face of great threat or danger is very widespread. However, it is not borne out in reality. Insofar as wild flight is concerned, the opposite behavioral pattern in most disaster is far more likely. People will often stay in a potentially threatening situation rather than move out of it. This really should be expected. Human beings have very strong tendencies to continue on-going lines of behavior in preference to initiating new courses of action.

2. Just as the panic image of disaster behavior is generally incorrect, so is the view that disasters leave victims dazed and disoriented both at time of impact and in the recovery period. Those who experienced disasters are not immobilized by even the most catastrophic of events. They are neither devoid of initiative nor passively dependent or expectant that others, especially relief and welfare workers, will take care of them and their disaster created needs. In fact, disaster victims sometimes insist on acting on their own even contrary to the expressed advice of the public authorities and formal agencies.

3. The assumption that local organizations are unable to cope with disasters is based both on the notion that these organizations and the communities in which they are located are overwhelmed by disaster impact, and also by the fear that the employees of these organizations are so affected by disaster impact that their efficiency is reduced. Neither of these notions stand up well under close observation.

4. The idea that disaster aftermath creates the conditions for the development of anti-social behavior is widespread. In particular, there is the assumption that widespread looting takes place. The term looting has military roots, implying invading

armies take property by force, generally when the rightful owner cannot protect it. During disasters, according to common belief, invading armies of opportunists take property left unguarded when the rightful owner is forced out by disaster. Because of the expectation that looting will occur, one does find that there is, within disaster-impacted communities, anxiety about the possibilities of looting and also reports of looting which confirm the initial expectation. On the other hand, those who have done disaster research have found it difficult to cite many authenticated cases of actual looting.

5. Contrary to popular image, morale in disaster-impacted communities is not destroyed. Partly as a result of the generation of altruism and the reaffirmation of equality . . . the result over time is an increase in collective morale. Such an increase may seem implausible since disasters create to a greater or lesser degree those who have immediate personal losses -- the death of a family member, injury to themselves or damage to their property. Victims, however, are always outnumbered by non-victims. Even in a community with a large number of "victims," their losses do not necessarily have a cumulative effect in lowering morale. Individual suffering is always experienced in reference to the plight of others. Suffering in the disaster context is not an isolated experience and, therefore, it does not become an isolating experience.

6. Patterns of leadership and of authority in disaster-impacted communities are very complex. Their complexity, however, is usually misinterpreted as confusion and the panacea of "strong leadership" is frequently offered as a solution without understanding the nature of the problem. Perhaps the beginning of understanding is to start with the observation that communities are not organized to cope with disasters. This is true even in communties with extensive pre-disaster planning since there is a considerable difference in anticipating problems and facing them. What disasters

> do is to create a series of new problems for the community and in doing this, they necessitate new relationships among its parts. Disasters force the development of a new structure which reflects the current involvement of various parts of the community which, in turn, can make decisions "for" the community.

Although the studies done by the Disaster Research Center and others (17,40) have dispelled the myths associated with peoples' behavior during a disaster, if the causative agent of the incident were radiation, would peoples' reactions be substantially different? The conclusion drawn by many is that because radiation is largely an unknown quantity, imperceptible to the ordinary senses, inherently, the fear of the unknown and its consequences would cause a different behavior pattern--perhaps similar to popular notions. This would, in turn, have a dramatic effect on evacuation involving a release of radioactivity.

Dr. Russell R. Dynes (41), Co-Director of the Disaster Research Center, was asked if he thought people would react differently--panic--because of a radiation threat. Dr. Dynes' reply was that there has been an overemphasis placed on the qualitative difference between radiation and other threats by both public officials and anti-nuclear groups, "What was assumed was that the nuclear advent represented some new juncture in human history and, therefore, it would evoke and demand a quite different level of human behavior." Dr. Dynes continued, "As I read history, there is not reason to suggest that because of the presence of a new 'order' of threat that human behavior would disintegrate into 'uncivilized' behavior."

The summation of Dr. Dynes' reply is that there is not reason to expect that people will react any differently because the disaster agent is radiation than they would for a flood, fire, or any other type of causative agent. This "normal" behavior is amply documented (37,39) and does not include panic.

Dr. Dynes further states:

> If your concern is primarily with evacuation, there is good reason to suggest that the problem in evacuation is not one of panic flight but the problem of getting people to move at all. The question of the perception of threat is a very complicated one and is not as obvious as many people assume it to be.

Based upon Dr. Dynes' response to the specific question of behavior to radiation versus other threats, corroborated by the research (40) that reveals the true behavior of people during a disaster as opposed to the panic conception, there is no reason to believe or assume that the risk of injury or death should be any higher due to an evacuation than the normal accident or injury rate.

> " . . . one fact is borne out by various data of past disasters: the freedom to escape from threat of death or injury has a calming effect on the population." (37)

Motivation to evacuate

In many cases, even when presented with a grave threat, people refuse to evacuate (16,23,28,40). Many reasons have been given both by persons who have not evacuated (17,23), and persons conducting the evacuation as to this reluctance to leave. To some degree, it is the individual's impressions and interpretation of the seriousness of the situation based on the official or unofficial information he/she receives. An individual evaluation is made and a positive or negative action elicited. It cannot be taken for granted that an official order to evacuate will be followed, even if it is a mandatory rather than a voluntary order. Results of this study indicate that approximately six percent of the total population refused to evacuate. Other reports indicate this figure can run higher than 50 percent (23).

There is no reason to believe that because the disaster agent is radiation rather than some other agent, that is, in itself, will provide sufficient motivation to leave. Rather, the opposite viewpoint should be taken--people will be hesitant to leave. Cognizance should be given in the planning stage to this problem and appropriate thought given to its remedy.

Warning systems and communication systems between evacuee-evacuator, evacuator-evacuator, and evacuator-news media-population play a significant role in the emergency and/or evacuation process (17,42,43). It is not only important that pretested, workable systems be available, but that an understanding of peoples' response and behavior to warning systems be recognized and be advantageously used.

Emergency plans

There have been many documents published on emergency and disaster planning (44-48), some of which are listed in the bibliography. It was not the intent of this report to go into this aspect; however, a number of thoughts and suggestions were expressed by individuals contacted concerning emergency plans that are most appropriate for evacuations.

Some of these thoughts and suggestions follow:

1. To keep it workable in practice, an emergency plan should be kept as simple as possible for the particular situation under study. The language should be kept on a level commensurate with the training and experience of those who must execute it.

2. Scheduled periodical reviews of the plan are needed in order to correct it for changing conditions, technology, and personnel.

3. Continual testing of the plan, as authentically as possible, is needed to determine whether it will work practically and to determine needed adjustments.

4. Many times emergency plans are written by individuals who have no real experience in emergencies and little or no knowledge of how people behave during an emergency. Consequently, plans are written that are contrary to peoples' behavior patterns. As an example, people will not evacuate an area, regardless of the danger, if their family group is separated, unless they know that members of their family are safe, accounted for, and that arrangements have been made for them to evacuate.

5. Some plans are written delegating responsibilities to persons or organizations that have not been informed of these responsibilities. In some cases, responsibilities are not transferred to new personnel involved in normal turnovers and position changes.

6. Two instances in the literature (16,22) are reported where delegated responsibilities were given to personnel, who, for various reasons, were not available during the disasters. Other studies do not cite this as a problem (39). Serious consideration, however, should be given to the selection of personnel who would be responsible for an evacuation. Pre-disaster arrangements should be made for the families of those responsible for the evacuation such that they are assured that their families are safe and they can devote full time to the emergency without concern for the safety of their families.

7. It is important that all personnel who will be involved in the evacuation have adequate training commensurate with their responsibilities during an incident. Training in radiological health and protection is especially important for the ancillary personnel needed to help with the evacuation, but who will not be doing actual health physics work. Their familiarity with the subject will assist them in their communications with the evacuees and will help them understand the situation themselves.

Problems encountered in various evacuations

Some of the problems encountered in the evacuations which were investigated, which may or may not be typical, are worthy of mention since they demonstrate situations that have occurred and will probably occur again.

It was mentioned by the Illinois Civil Defense (21) that one of the problems that they seem to routinely encounter in emergencies and subsequent evacuations is premature childbirth. In Illinois prior arrangements are made in evacuation plans for this problem.

It was pointed out by a number of individuals contacted and in literature reviewed, that problems occur in the pre- and post-evacuation (16,22,23). In a number of instances, where an evacuation was imminent but not announced, traffic congestion and confusion existed as people rushed to gas-up and stock-up on food. This, in turn, has interfered with movement of traffic such that emergency vehicles have been impeded. Inbound traffic moving towards the impact area was diverted to relieve congestion in one situation (35,49).

Post-evacuations, depending upon location, pose problems of preventing unwanted people from coming into the impact area while permitting access to the inhabitants and emergency workers. Some personnel control was exercised by the use of passes. Residents, in some cases, became angry at roadblocks when denied access to their homes and businesses. Many persons have evacuated some distances from the impact area and the local news media where they were sheltered did not broadcast information concerning reentry advice. Therefore, the evacuees stayed away longer than necessary.

In many types of emergency situations, a convergence behavior has been amply demonstrated (41). Peoples' curiosity overrides their fear of danger. Consequently, this results in the people not leaving the area promptly or in people outside the affected area coming in to sightsee. This convergence on a disaster interferes with the movement of people out of the area (evacuees) and interrupts and interferes with the movement of official traffic--impeding evacuation efforts.

Sightseeing from aircraft has also interfered with necessary aerial missions over an impact area. In several instances, Federal Aviation Administration Regulations were invoked to limit the airspace to air traffic associated with the incident.(50) In most evacuations, people use their private vehicles. Traffic moves in an orderly fashion, and slower, due to crowded roads. Minor accidents, mechanical problems, and lack of gasoline may cause congestion and slow the evacuation. In some of the evacuations, tow trucks and gasoline trucks were spaced along the evacuation route, along with good police patrol, to keep traffic flowing smoothly. Cars with mechanical breakdowns were pushed off the road and their occupants were absorbed in other evacuating vehicles.

In one evacuation investigated, a problem was encountered with a non-English-speaking population group. Not only was time lost in obtaining an interpreter, but the people would not evacuate to the shelter area because it was established for a different ethnic group; therefore, they had to be directed to another location (51).

The security of the area must be firmly established and people living in that area must be positively aware that, if an evacuation occurs, their property will be protected against fire, theft, and other hazards and wanton destruction. This knowledge helps persuade people to evacuate when necessary.

Looting is frequently reported during disaster situations. In the cases that have been investigated (16,40), even though extensive looting had been reported, it generally turned out that the reports were mainly rumors. In other than civil disturbances, it has been difficult to verify cases of looting (40,52). In many events, crime rates actually decrease. It is conjectured that, to some degree, the absence of looting is due to increased security of the area.

Frequently, there is an over-response of voluntary help in disaster assistance. Many volunteers from different organizations present themselves at scenes of incidents. Judicious use of their talents and equipment may help relieve some of the evacuation problems. In one instance, so many volunteers presented themselves that they actually caused logistic problems.

Shelters and evacuation centers are usually quickly established and manned; they are generally located in public buildings, especially schools. Although they are readily available, relatively few people use these centers, preferring to find their own accomodations either commercially or with friends or relatives. In a California flood, only 9,260 out of 50,000 persons evacuated registered in the 38 Red Cross shelters; during Hurricane Carla, 75 percent of the evacuees went to other than public shelters; and during Hurricane Betsy, only 20 percent requested assistance (23,40). Generally, shelter centers are used only if nothing else is available or if one cannot financially care for himself.

It is necessary, in an evacuation called due to a radiation threat, to be able to warn all citizens in the affected area and to account for them later. Accounting for people at a shelter may prove impractical since the probability is that only a small percent will use public shelters. Therefore, some other accountability systems will need to be devised.

Aside from adequate, redundant communication systems, the helicopter was mentioned as a most valuable assest in disaster situations. Not only does it make quick movement available, but, as a movable observation point, a helicopter is invaluable.

Special evacuations

In the event of a nuclear incident, some institutions, public and private, may have to be evacuated. Each institution will have its own particular characteristics and will require different procedures for handling the evacuees.

Schools

In most of the evacuations observed, more than 99 percent of the evacuees utilized private vehicles for the evacuations and evacuated as family units. If schools are evacuated, it may result in the separation of families. Parents are reluctant to be separated from their children and may attempt to retrieve them, causing additional congestion and, subsequently, may slow down the evacuation process. In order to minimize the congestion, plans should be developed whereby school children would be returned to their respective residences or evacuated to a specific location. The location could be schools located out of the impact area since they would present a somewhat familiar environment and generally have food service facilities and adequate supervision. The choice of either action would be dependent upon an appraisal of the affected area. In either case, the parents should be advised of the type of action to be taken in order that appropriate family plans can be made.

Hospitals

Five hospital evacuations were recorded on the questionnaires with no injuries or deaths reported. One hospital underwent "vertical evacuation" where the patients were moved to higher floors because of a tsunami and four were evacuated to other areas. Specific data on numbers of patients moved were available for only three hospitals and involved 550 patients.

The general procedures used during the hospital evacuations were to discharge the ambulatory patients and transport the nonambulatory patients by police-escorted ambulances to other receiving hospitals. In one case, nonambulatory patients were moved to a 200-bed disaster hospital and those that were in intensive care were moved to another regular hospital.

Two problems arose during one evacuation. These were: failure to send records with patients and failure to provide at least 24 hours of medication. It was strongly emphasized, by the respondees during telephone interviews, that the hospital evacuations could not have been accomplished smoothly without injury or loss of life without detailed planning and coordination.

Penal institutions

Several penal institutions were evacuated in the incidents investigated and involved a state penitentiary, a county jail, and a city jail. The city jail underwent "vertical evacuation," while the county jail and state penitentiary inmates were evacuated by buses, designed for prisoner transfer, to other areas. The state penitentiary prisoners were evacuated to a football field, while the county prisoners were absorbed into other correctional institutions.

It appears that jails and prisons may be effectively evacuated if adequate planning and reception centers are available. If, however, evacuation is not feasible or desirable, the shielding effects provided by buildings of the institution should be determined. Dose equivalence may be set at higher levels for prisoners and guards than for the general public if the risk associated with evacuation is unacceptable.

Nursing homes

One nursing home evacuation was documented from the incidents. A special train was provided which moved and housed the occupants 50 miles from the point where a possible chlorine release could have occurred.

It appears that private and public institutions can be evacuated safely, with little risk, in the event of a nuclear incident provided adequate planning has been made and a reception or care center has been designated out of the impact area.

CONCLUSIONS

Based on the study of individual evacuations and consultation with persons having experience in managing and studying various aspects of evacuations, some general conclusions can be made:

1. Advanced planning is essential to identify potential problems that may occur in an evacuation.

2. The risk of injury or death to evacuees does not change as a function of the numbers of persons evacuated.

3. The risk of injury or death to evacuees can be approximated by the National Highway Safety Council statistics for motor vehicle accidents, although subjective information suggests that the risks will be lower.

4. Most of the evacuees utilize their own personal transportation during an evacuation.

5. Most of the evacuees assume the responsibility of acquiring food and shelter for themselves.

6. Evacuation costs are highly area-dependent and should be computed based on local demographic, economic, and geographic conditions.

7. No panic or hysteria has been observed in evacuations.

In summary, large or small population groups can be effectively evacuated from impact areas with minimal death and injury risks and, in most cases, they can take care of themselves provided adequate plans are developed and executed to minimize potential problems that may occur peculiar to the impact area. Costs would probably not be a deterrent in initiating an evacuation.

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APPENDIX A

QUESTIONNAIRE—EVACUATION STATISTICS

REQUESTING ORGANIZATION:

U.S. Environmental Protection Agency
Office of Radiation Programs
P.O. Box 15027
Las Vegas, NV 89114

Telephone: 702-736-2969, x305

PURPOSE:

This questionnaire has been prepared to obtain information from past evacuations that can be utilized in assessing risks of evacuations that may occur in the event of an incident at a fixed nuclear facility. The risks that need to be determined are cost, injury, and death which may take place as a result of evacuations associated with different scenarios.

I. INCIDENT OR DISASTER DESCRIPTION:

Flood ( ) Flash Flood ( ) Fire ( ) Hurricane ( ) Storm ( )

ransportation ( ) Earthquake ( ) Tsunami ( ) Other ( ) please

describe ____

____

Date(s) of occurrence: ______________________
Day Month Year

Location: ____
City, Town or Village County/Parish State

Brief description of incident or disaster ____________________

____

____

____

____

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II. ADMINISTRATIVE:

Person Completing Questionnaire:

Name ____

Address ____

Telephone ________________

Person or Organization Ordering or Requesting Evacuation:

Name/Title ____

Address ____

Telephone ________________

Person or Organization which Supervised Evacuation:

Name/Title ____

Address ____

Telephone ________________

Other Persons or Organizations which may Provide Additional Information:

Name/Title ____

Address ____

Telephone ________________

Name/Title ____

Address ____

Telephone ________________

Was the evacuation : . . voluntary (advised) ( ) or involuntary (ordered) ( )

Were evacuation plans available? Yes ( ) No ( )

Were evacuation plans followed? Yes ( ) No ( )

Was there a prewious evacuation since 1960? Yes ( ) No ( )

III. DESCRIPTION OF AREA EVACUATED:

Rural-Farming ( )   Rural-Residential ( )   Suburban ( )   Urban ( )

Industrial ( )   Commercial-Fishing ( )   Recreation ( )

Other ( ) please describe ____

____

Areas or buildings posing special problems during evacuation, such as hospitals, prisons, rest homes, etc.:

Comments ____

____

____

____

____

____

Approximate size of area evacuated:

Number of square miles ______________ or city blocks ______________

IV. NUMBER OF PERSONS EVACUATED:

Number: ______________________

V. NUMBER OF PEOPLE WHO DID NOT EVACUATE ALTHOUGH ADVISED TO DO SO:

Number: ______________________

VI. WEATHER CONDITIONS AT TIME OF EVACUATION:

Rain ( )   Snow ( )   Clear ( )   Cloudy ( )

Cold, 0-32° ( )   Moderate, 32-50° ( )   Warm, 50-100°

Day ( )   Night ( )   Dawn ( )   Dusk ( )

VII. ROADS USED FOR EVACUATION

Primary Evacuation Routes
(Privately Owned Vehicles Only)

	Urban	Suburban	Rural	Expressway Unlimited Access	Expressway Limited Access
Length of Route Used (miles)	( )	( )	( )	( )	( )
Number of Deaths Caused by Evacuation	( )	( )	( )	( )	( )
Number of Injuries (Requiring Medical Attention) Caused by Evacuation	( )	( )	( )	( )	( )
Road Conditions During Evacuation					
Dry	( )	( )	( )	( )	( )
Wet	( )	( )	( )	( )	( )
Snow/Ice	( )	( )	( )	( )	( )

Comments:

VIII. ROADS USED FOR EVACUATION

Primary Evacuation Routes
(Supplied Vehicles Only)

	Urban	Suburban	Rural	Expressway Unlimited Access	Expressway Limited Access
Length of Route Used (miles)	( )	( )	( )	( )	( )
Number of Deaths Caused by Evacuation	( )	( )	( )	( )	( )
Number of Injuries (Requiring Medical Attention) Caused by Evacuation	( )	( )	( )	( )	( )
Road Conditions During Evacuation					
Dry	( )	( )	( )	( )	( )
Wet	( )	( )	( )	( )	( )
Snow/Ice	( )	( )	( )	( )	( )

Comments: ____

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IX. OTHER KINDS OF EVACUATIONS:

	Number of Persons Evacuated	Distance (Miles)	Injuries Caused by Evacuation	Deaths Caused by Evacuation
Boat	( )	( )	( )	( )
Airplane	( )	( )	( )	( )
Helicopter	( )	( )	( )	( )

X. TIME ELEMENTS:

Time between evacuation and onset of incident or disaster ______________ hours

Approximate time required to complete evacuation ______________ hours

Approximate time persons were in evacuation status ______________ hours

Additional comments or explanations: ______________________________

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XI. COST OF EVACUATION:

Approximate cost of the evacuation ______________ dollars

Evacuation cost breakdown (if available) -- for example: National Guard, city police, Red Cross shelters, loss of wages, etc.

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XII. Have any reports been written on this evacuation? If so, please forward a copy (if available) to us.

APPENDIX B

SUMMARY OF EVACUATION QUESTIONNAIRES

EVENT NUMBER	LOCATION, DATE AND CAUSE FOR EVACUATION	TYPE OF AREA EVACUATED	AREA EVACUATED (SQ. MILES)	NUMBER OF PERSONS EVACUATED	DISTANCE (MILES) EVACUATED	EVACUATION TIME (HOURS)	DEATHS	INJURIES	TIME PERSONS IN EVACUATION STATUS (HOURS)	POPULATION DENSITY #/SQ. MILE	PERSON-MILES x 10^3	TIME BETWEEN EVACUATION AND ONSET OF INCIDENT (HOURS)	ROAD AND CONDITIONS *	WEATHER	TIME OF DAY	EVACUATION PLANS†	REMARKS
1	Clatsop Co., OR; 1/11/72; Flood	Rural Farming	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D	N.D.	N.D.	N.D.	Wet. N.D.	Rain	Day Night	P	Some moved to higher ground to neighbors
2	Clatsop Co., OR; 1/8/71; Flood	Surburban	0.02	10 of 300	N.D.	N.D.	0	0	N.D.	15,000	N.D.	N.D.	Wet USR	Rain	Day Night	PU	Private vehicles
3	Clatsop Co., OR; 12/22/64; Flood	Rural Farming	N.D.	2 of 120	N.D.	0.5	0	0	16	N.D.	N.D.	N.D.	Wet N.D.	Rain	Day	PU	Private vehicles
4a	Okanogan Co., WA; 5/72; Flood	Rural Farming; Rural Residential; Urban	5.0	740	1.0	1.25	0	0	240	N.D.	740	N.D.	Wet R	Rain	Day Night	PU	Mixed areas; Private vehicles
4b	Okanogan Co., WA; 5/72; Flood	"	5.0	450	1.0	1.25	0	0	240	N.D.	450	N.D.	Wet R	Rain	Day Night	PU	Supplied vehicles
4c	Okanogan Co., WA; 5/72; Flood	"	N.D.	48	0.1	N.D.	0	0	240	N.D.	4.8	N.D.	N.A.	Rain	Day Night	PU	Boat evacuation
5	Douglas Co., WA; 9/6/72; Flash Flood	Suburban	2.0	50 of 3000	1.0	2.0	0	0	24	1000	50	0	Wet S	Rain	Night	N.D.	Private vehicles

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6a	Ferndale, WA; 1/8/71; Flood	Rural Farming; Fishing	30	60	10	4.0	0	1	288	6.7	600	72	Wet R	Rain	Day Dusk	PU	Private vehicles; Indian Reservation; Heart attack
6b	Ferndale, WA; 1/8/71; Flood	"	30	140	8.0	4.0	0	0	288	6.7	1.12k	72	Wet R	Rain	Day Dusk	PU	Supplied vehicles
6c	Ferndale, WA; 1/8/71; Flood	"	30	25	1.0	4.0	0	0	288	6.7	25	72	N.A.	Rain	Day Dusk	PU	Boat evacuation
7	Chehalis Indian Reservation, WA; 12/22/72; Flood	Rural Farming	8.0	38	25	2	0	0	84	N.D.	950	3	Wet R	Rain	Night	PU	Private vehicles
8	Shoreline WA; 3/64, Tsunami	Recreation	35	900	20	1.0	0	0	6.0	69	18,000	1.25	Dry R	Clear	Night	PU	Private vehicles; Coast line evacuated; 1500 transients; Vacationers present
9	Port Angeles, WA; 6/16/61; Flood	Suburban	1.0	100	0.5	2	0	0	N.D.	N.D.	50	40	Wet U	Rain	Night	P	Private vehicles
10	Port Angeles, WA; 10/1/71; Fire	Urban	0.01	50	1.0	N.D.	0	0	N.D.	N.D.	50	0	Dry U	Clear	Night	NP	Private vehicles
11	Prairie City, OR; 6/69; Flash Flood	Rural Residential	0.5	30	1.0	N.D.	0	0	720	60	N.D.	0	Wet R	Rain	Night	NP	Drive-out; Walk-out; Boat; No Breakdown
12	Downington, PA; 2/5/73; Transportation	Suburban	0.25	700 of 800	1.0	2.0	0	0	6.5	3200	700	1.0	Dry S	Cloudy	Night	PU	Private vehicles

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13	Crystal City, CA; 3/28/64; Tsunami	Urban	0.5	N.D.	0.5	N.D.	0	0	72	N.D.	N.D.	0.75	Dry U	Clear	Night	PU	Private vehicles; Jail & Hospital evacuated to higher floors
14	Cannon Beach and Seaside, OR; 3/28/64; Tidal wave	Urban	3.5	3,100 of 3,700	2.0	1.5	0	1	5.0	1,057	6,200	0	Wet USR	Cloudy	Night	N.D.	Mostly walk-out; Part of town not alerted due to short warning
15	Logansport, LA; 5/16/69; Transportation	Suburban; Urban	13	1,800	2.0	N.D.	0	0	24	138	3,600	0.3	Dry S	Clear	Day	NP	Private vehicles
16	Creve Coeur, IL; 8/1/61; Transportation	Rural Residential; Suburban; Urban	15	7,500	12	1.0	0	0	5.5	500	90,000	0	Dry S	Fog	Night	PU	Private vehicles
17	Wilkes Barre, PA; 6/23/72; Flood	Urban	5.0	75,000 of 78,000	1.0	5.0	0	0	120	15,600	75,000	5	Wet U	Rain	Dawn Day	PU	Hospitals and Jail evacuated
18	Chadbourne, NC; 1/13/68; Transportation	Suburban	0.5	350	1.0	5.0	0	0	48	700	350	0	Dry S	Cloudy	Dusk Night	NP	Private vehicles
19	Port Aransas, TX; 9/61; Hurricane	Urban	1.3	2,800 of 4,000	50	2.0	0	0	N.D.	3,100	140,000	48	Dry R	Cloudy	Day	PU	Private vehicles
20	Robestown, TX; 7/3/70; Hurricane	Urban	0.08	450	3.5	1.5	0	0	168	5,600	1,575	0	Wet R	Rain	Dusk	PU	Supplied vehicles
21	Payson, AZ; 9/70; Flash Flood	Rural Residential; Recreation	20	160	1.0	12	0	0	N.D.	8	160	0	Wet R	Rain	Day	PU	Private vehicles

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22	Chambers Co., TX; 9/3/71; Hurricane	Rural Farming	336	10,000 of 10,200	50	7.5	0	0	72	30	500,000	48	Wet UR	Rain Gale	Day Night	PU	Private vehicles
23	Greely, CO; 4/12/73; Dam Break	Rural Residential	3.0	1,000	1.0	3.5	0	0	24	330	1,000	7.5	Dry S	Clear	Day	PU	Private vehicles
24	Portland, OR; 12/7/55; CD Test Evacuation	Urban	4	101,000	1.5	0.5	0	0	N.D.	25,000	151,500	N.A.	Wet U	Rain	Day	PU	Private vehicles
25	Isleton, CA; 6/21/72; Flood	Suburban	11	1,200	40	11	0	0	2,160	109	48,000	14	Dry EU	Clear	Day	NP	Private vehicles
26	Humbolt Co., CA; 12/22/64; Flood	Rural Residential	450	183	25	N.D.	7	0	N.D.	N.D.	4,600	N.D.	N.A.	Rain	Day	P	Helicopter evacuation
27a	Glenn Co., CA; 2/73; Flood	Rural Farming	20	30	6	4.0	0	0	N.D.	N.D.	180	N.D.	N.A.	Rain	Day Night Dawn Dusk	N.D.	Helicopter evacuation
27b	Glenn Co., CA; 2/73; Flood	Rural Farming	20	20	6	N.D.	0	0	N.D.	N.D.	120	N.D.	Wet R	Rain	"	N.D.	Supplied vehicles
28	King Co., WA; 3/59; Flood	Rural Farming	20	500 of 512	10	18	0	0	192	26	5,000	72	Wet R	Rain	Day Dusk Night	PU	Private vehicles
29	Kelso, WA; 1/18/72; Flood	Rural Residential	10	70	5	48	0	0	2,160	7	350	24	Wet R	Rain	Night	PU	Private & Supplied vehicles; No breakdown on use
30a	Port Arthur, TX; 9/3/61; Hurricane	Hospital	N.D.	80	20	4	0	0	72	N.D.	1,600	48	Dry R	Clear	Day	PU	Hospital evacuation; ambulatory by private vehicles

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30b	Port Arthur, TX; 9/3/61; Hurricane	Hospital	N.D.	20	20	4	0	0	72	N.D.	400	48	Dry R	Clear	Day	PU	Hospital; non-ambulatory; ambulance evacuation
31	Jefferson Co., TX; 9/3/61; Hurricane	Suburban; Urban; Industrial	945	108,600 of 113,600	80	7.5	0	0	72	120	8,688,000	48	Dry S	Clear	Day	PU	Private vehicles; Predominantly large scale urban evacuation
32	Hagerstown, MD; 2/27/68; Transportation	Suburban	0.06	2,500	N.D.	N.D.	0	0	12	42,000	N.D.	0	Dry S	Clear	Night	NP	Private vehicles
33	Wetanka, OK; 4/4/69; Transportation	Rural Residential	3	2,000	25	8	0	0	27	667	50,000	0	Dry S	Cloudy	Day	PU	Private vehicles
34	Louisville, KY; 3/19/72; Transportation	Urban	0.35	4,000	1	3	0	0	24	11,400	4,000	N.D.	Wet U	Rain	Day	PU	Private vehicles; Chlorine barge; No chlorine release
35	Urbana, OH; 8/13/69; Transportation	Suburban	3.1	4,000	0.75	3.5	0	0	24	1,300	3,000	0	Dry S	Clear	Dawn	N.D.	Private vehicles
36	Baton Rouge, LA; 8/65; Transportation	Urban	8	150,000	30	2.0	0	0	5.0	19,000	4,500,000	N.D.	Dry U EU,	Clear	Day	PU	Private vehicles; Chlorine barge; No chlorine release
37	St. Marys Parish, LA; 9/64; Hurricane	Rural Residential; Urban	1,036	40,500 of 45,000	150	8	0	0	72	43	6,075,000	12	N.D. U	N.D.	N.D.	PU	Private vehicles
38	Morgan City, LA; 1/19/73; Transportation	Urban	1.8	3,000 of 3,300	2	4	0	0	60	1,800	6,000	6	Ice U	Snow	Day	PU	Private vehicles Chlorine barge; No chlorine release
39	Texarkana, TX; 8/27/67 Transportation	Suburban	9.0	5,000	3	4	0	0	4.0	550	15,000	1	Dry U	Clear	Night	NP	Private vehicles

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40	Grand Valley, CO; 9/10/69; Nuclear Detonation (Plowshare)	Rural Farming; Industrial	20	300 of 307	5	1.0	0	0	7.0	15	1,500	4	Dry R	Cloudy	Day	PU	Private vehicle; Heavily planned and supervised
41	Grand Isle, LA, 9/3/61; Hurricane	Rural Residential; Industrial	1.8	2,200 of 2,300	70	3.5	0	0	N.D.	1,300	154,000	82	Wet R	Rain	Day Dusk	NP	Private vehicles
42	Los Angeles, CA; 2/9/71; Earthquake	Suburban	12	80,000	N.D.	7	0	0	240	6,700	N.D.	3	Dry U	Clear	Day	N.D.	Private vehicles
43	Seabrook IS, SC; 1/19/59; Hurricane	Suburban	4.5	208	0.6	4	0	0	12	46	125	10	N.A.	Rain	Day Dusk Night	PU	Boat evacuation
44	Glendora, MS; 9/11/69; Transportation	Rural Farming; Rural Residential; Suburban; Urban	1,200	35,000	20	4	0	0	9.0	29	700,000	5	Dry S	Cloudy	Night	P	Private vehicles
45a	Anderson, SC; 7/9/68; Flash Flood	Suburban	0.09	60	0.06	2	0	0	24	1,700	3.6	0	N.A.	Rain	Night	NP	Boat evacuation
45b	Anderson, SC; 7/9/68; Flash Flood	Suburban	0.09	150	0.75	2	0	0	24	1,700	200	0	Wet U	Rain	Night	NP	Supplied vehicles
46a	TX; 9/3/61; Hurricane	All types	N.D.	501,000	N.D.	N.D.	0	0	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	Persons from events # 22 & 31 subtracted from total

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46b	Plaquemines Parish, LA; 9/3/61; Hurricane	All types	N.D.	22,000	N.D.	N.D.	0	0	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	Private vehicles
47	Lafourche Parish, LA; 9/11/61; Hurricane	Rural Farming	100	23,000 of 37,000	50	9	0	0	168	370	1,025,000	13	Wet R	Rain	Night	PU	Private vehicles
48	Biloxi, MS; 9/11/61; Hurricane	Urban	7.7	15,000 of 20,000	5	5	0	0	12	2600	75,000	20	Dry S	Clear	Dawn Dusk	PU	Private vehicles
49	Gulfport, MS; 8/69; Hurricane	Urban; Industrial	15	10,000 of 10,500	10%-200 90%-0.5	7.5	1	0	24	700	204,000	12	Wet Dry U EU	Clear	Day	PU	Private vehicles; Death resulted from heart attack during evacuation; died in shelter
50	Cane Run, KY; 7/20/71; Flash Flood	Urban; Rural; Farming	9	1,500 of 1,515	13	36	0	0	48	167	19,500	0	Wet Dry R	Clear	Day Night Dawn	NP	Private vehicles; Slowly developing incident; evacuation occured in stages
51	Cumberland, KY; 12/14/72; Landslide	Urban; Suburban	0.5	150	5.5	1.0	0	0	N.D.	300	825	0	Wet R	Rain Snow	Dusk	PU	Private vehicles
52	Los Angeles, CA; 12/14/73; Dam Break	Urban	0.49	8,500	N.D.	2	2	0	N.D.	17,300	N.D.	4	Dry S	Clear	Day	NP	Private vehicles; Deaths due to driving wrong way into deep water
53a	Florence Co., SC; 2/3/73; Flood	Rural Residential	6	90	6	8	0	0	4.0	15	540	N.D.	Wet R	Clear	Night	PU	Private vehicles
53b	Florence Co., SC; 2/3/73; Flood	Rural Residential	6	9	6	N.D.	0	0	4.0	15	54	N.D.	N.A.	Clear	Night	PU	Boat evacuation

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54	Minot, ND; 5/69; Flood	Urban	5.0	12,000	1	N.D.	0	0	N.D.	2,400	12,000	N.D.	Wet U	N.D.	Day Dusk Night	PU	Private and supplied transportation; No breakdown
55a	Grand Forks, ND; 4/65; Flood	Rural Residential	0.25	190	2	N.D.	0	0	N.D.	760	380	N.D.	Wet R	Snow	Day	NP	Private vehicles
55b	Grand Forks, ND; 4/65; Flood	Rural Residential	0.25	20	1.0	N.D.	0	0	N.D.	760	20	N.D.	N.A.	Snow	Day	NP	Boat evacuation
56a	Jamestown, ND; 4/69; Flood	Urban	1.0	350 of 354	1.0	24	0	0	72	354	350	N.D.	Wet U	Clear	Day	NP	Private and supplied transportation; No breakdown
56b	Jamestown, ND; 4/69; Flood	Urban	1.0	12	0.5	N.D.	0	0	72	354	6	N.D.	N.A.	Clear	Day	NP	Boat evacuation
57	KY; 7/65 to 12/72; Floods; Tornadoes	N.D.	N.D.	3,400	N.D.	N.D.	0	0	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	Summary sheet data; No breakdown on evacuation modes
58	Aiken, SC; 4/15/69; Flood	Suburban	0.05	35	0.25	0.45	0	0	12	700	8.8	0.5	Wet S	Rain	Night	NP	Very small area evacuated; Private vehicles
59	Milton, FL; 6/70; Flood	Suburban	N.D.	68	N.D.	N.D.	0	0	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	Private vehicles

ROAD AND CONDITIONS *
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APPENDIX C

INFORMATION BASES COMPUTER SEARCHED FOR EVACUATION REFERENCES

1. Environmental Information Retrieval, On-Line (ENVIRON)
2. Institute for Scientific Information (ISI)
3. Machine Readable Catalog (MARC II)
4. National Technical Information Service (NTIS)
5. Current Index to Scientific and Technical Literature (PANDEX)
6. Defense Civil Preparedness Agency (DCPA)
7. Office of Emergency Preparedness (DCPA)
8. Office of Emergency Preparedness (OEP)
9. National Safety Council (NSC)
10. American Red Cross (ARC)
11. Department of Health, Education, and Welfare (DHEW)

APPENDIX D

NATIONAL CONTACTS

1. Nuclear Energy Liability Insurance Association
   New York, NY

2. Atomic Industrial Forum, Inc.
   New York, NY

3. National Association of Independent Insurers
   Des Plaines, IL

4. American National Red Cross
   Washington, DC

5. Radiological Hygiene Section
   Tennessee Valley Authority
   Muscle Shoals, AL

6. National Hurricane Center
   Coral Gables, FL

7. Disaster Project
   Council of State Governments
   Washington, DC

8. Highway Safety Research
   University of Michigan

9. Traffic Instruction
   Northwestern University
   Evanston, IL

10. Systems Development Corporation
    Santa Monica, CA

11. Highway Users Federation for Safety and Mobility
    Washington, DC

12. National Safety Council
    Chicago, IL

13. Advisory Committee on Emergency Planning
    NAS, Washington, DC

14. Environmental Protection Agency
    EOCC, Durham, NC

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15. U.S. Coast Guard
Cargo and Hazardous Materials Division

16. Environmental Protection Agency
OHM

17. Institute for Defense Analysis
Arlington, VA

18. Research Division
Defense Civil Preparedness Agency
Washington, DC

19. Center for Short-Lived Phenomena
Cambridge, MA

20. Dr. John A. Hammes
University of Georgia
Atlanta, GA

21. Engineering Systems Division
Stanford Research Institute
Menlo Park, CA

22. Dr. G. Hoyt Whipple
University of Michigan
Ann Arbor, MI

23. Disaster Preparedness Division
Washington, DC

24. Support Systems Research Division
Defense Civil Preparedness Agency
Washington, DC

25. Department of Transportation
Washington, DC

26. Hazardous Materials Branch
OMP, Environmental Protection Agency
Washington, DC

27. Division of Behavioral Sciences
National Academy of Sciences
Washington, DC

28. Institute of Behavioral Sciences
University of Colorado
Boulder, CO

29. Inquiry Unit
National Bureau of Standards
Washington, DC

30. Southern Interstate Nuclear Board
Atlanta, GA

31. United Services Automobile Association
San Antonio, TX

32. Disaster Research Center
Ohio State University
Columbus, OH

33. Earthquake Planning Group
Disaster Preparedness Division
Office of Emergency Preparedness
Washington, DC

34. Division of Emergency Services
U.S. Public Health Service
Washington, DC

35. Defense Civil Preparedness Agency
Pentagon
Washington, DC

APPENDIX E

REGIONAL CONTACTS

1. Defense Civil Preparedness Agency
   Region VIII
   Bothell, WA

2. Disaster Assistance Support Team
   Environmental Protection Agency
   Region VIII
   Denver, CO

3. Environmental Protection Agency
   Region VIII
   Denver, CO

4. Defense Civil Preparedness Agency
   Region VI
   Denver, CO

5. Environmental Protection Agency
   Region III
   Philadelphia, PA

6. Environmental Protection Agency
   Region X
   Seattle, WA

7. Environmental Protection Agency
   Region V
   Chicago, IL

8. Field Operations
   Defense Civil Preparedness Agency
   Region IV
   Battle Creek, MI

9. Environmental Protection Agency
   Region II
   New York, NY

10. Field Operations
    Defense Civil Preparedness Agency
    Region V
    Denton, TX

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11. Environmental Protection Agency
Region IV
Atlanta, GA

12. Field Operations
Defense Civil Preparedness Agency
Region I
Maynard, MA

13. RADEF
Defense Civil Preparedness Agency
Region II
Olney, MD

14. Defense Civil Preparedness Agency
Region VI
Denver, CO

15. Field Operations
Defense Civil Preparedness Agency
Region VII
Santa Rosa, CA

16. Environmental Protection Agency
Region VI
Dallas, TX

17. Defense Civil Preparedness Agency
Region III
Thomasville, GA

18. Environmental Protection Agency
Region VII
Kansas City, MO

19. Office of Emergency Preparedness
Region IX

20. Office of Emergency Preparedness
Region IV
Atlanta, GA

21. Regional Field Office
Defense Civil Preparedness Agency
Region V
Denton, TX

22. Office of Emergency Preparedness
Region IX

APPENDIX F

STATE AND LOCAL CONTACTS

1. Salvation Army
   Las Vegas, NV

2. Operations and Training
   Civil Defense, State of Ohio
   Columbus, OH

3. Civil Defense, State of Louisiana
   Baton Rouge, LA

4. Civil Defense, State of Kentucky
   Frankfort, KY

5. Civil Defense, State of Illinois
   Springfield, IL

6. Nevada Safety Council
   Las Vegas, NV

7. Defense Civil Preparedness Agency
   Denton Federal Center
   Denton, TX

8. Civil Defense
   Carson City, NV

9. Pennsylvania State Council for Civil Defense
   Harrisburg, PA

10. U.S. Civil Defense Council
    Portsmouth, VA

APPENDIX G

LISTING OF EVENTS REQUIRING EVACUATION FROM 1960 TO 1973

HURRICANES*

		Number Evacuated
1.	DONNA September 4-12, 1960	No Data
2.	CARLA Texas to Louisiana September 11, 1961	300,000-800,000
3.	CINDY Texas September 16-19, 1963	No Data
4.	CLEO Florida, Georgia, and Virginia August 20 - September 5, 1964	No Data
5.	DORA Florida, Georgia, and Virginia August 28 - September 16, 1964	50,000
6.	HILDA Louisiana September 28 - October 5, 1964	150,000
7.	BETSY Florida and Louisiana August 27 - September 12, 1965	No Data
8.	ALMA Florida and North Carolina June 4-14, 1966	No Data
9.	INEZ Florida September 21 - October 11, 1966	No Data
10.	BEULAH Texas September 5-22, 1967	No Data
11.	ABBEY Florida June 1-13, 1968	No Data

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12.	GLADYS Florida October 13-21, 1968	No Data
13.	CAMILLE Mississippi and Virginia August 5-22, 1969	No Data
14.	BECKY Florida July 1970	No Data
15.	CELIA Texas July 3, 1970	No Data
16.	FERN Texas September 3-13, 1971	No Data
17.	EDITH Louisiana September 5-17, 1971	No Data
18.	GINGER North Carolina September 5 - October 5, 1971	No Data
19.	AGNES Florida to Pennsylvania June 19-29, 1972	No Data

*Taken from Climatological Data, National Summary, 1964-1971.

TRANSPORTATION

CHLORINE BARGE INCIDENTS*

		Number Evacuated
1.	Sunk Chlorine Barge March 1961 Mississippi	No Data
2.	Sunk Chlorine Barge during Hurricane August 1965 Louisiana	150,000
3.	Chlorine Barge Jammed in Bridge March - April 1972 Kentucky	4,000
4.	Chlorine Barge Jammed in Bridge January 1973 Louisiana	2,000

*Data obtained from U.S. Coast Guard.

RAILROAD INCIDENTS

		Number Evacuated
1.	August 24, 1964 Chillicoathe, Missouri	No Data
2.	February 23, 1965 Southern Toinette, Alabama	No Data
3.	September 26, 1965 Westfire, Oregon	300 Persons
4.	November 9, 1965 Monticello, Indiana	No Data
5.	November 12, 1965 Frazer, Pennsylvania	44 Persons
6.	December 4, 1965 Cambden, Arkansas	1,000 Persons
7.	August 28, 1966 Verona, Kentucky	No Data
8.	November 11, 1966 Homer, Michigan	No Data
9.	November 11, 1966 Cedar, Mississippi	No Data
10.	March 5, 1967 Litchfield, Illinois	30-40 Persons
11.	March 19, 1967 Albany, New York	No Data
12.	May 28, 1967 Switzer, South Carolina	No Data
13.	August 27, 1967 Texarkana, Texas	5,700 Persons
14.	November 18, 1967 Waterford, Alabama	2,800 Persons

15.	October 28, 1967 Danbury, Texas	1,200 Persons
16.	January 1, 1968 Dunreith, Indiana	236 Persons
17.	January 1, 1968 Geary, Oklahoma	15 Persons
18.	January 13, 1968 Chadbourne, South Carolina	1,500 Persons
19.	February 14, 1968 Lamison, Alabama	No Data
20.	February 27, 1968 Hagerstown, Maryland	2,500 Persons
21.	March 4, 1968 Shattuck, Oklahoma	No Data
22.	April 21, 1968 Kelley, Iowa	240 Persons
23.	May 7, 1968 Lilesville, North Carolina	No Data
24.	May 21, 1968 McHenry, Kentucky	No Data
25.	August 13, 1968 Urbana, Ohio	4,000 Persons
26.	November 5, 1968 Provo, Utah	No Data
27.	January 15, 1969 Springville, Alabama	No Data
28.	January 23, 1969 Brantham, Pennsylvania	No Data
29.	January 25, 1969 Laurel, Mississippi	1,000 Persons
30.	February 18, 1969 Crete, Nebraska	400 Persons

31.	March 17, 1969 Powder Springs, Georgia	No Data
32.	April 4, 1969 Wetamka, Oklahoma	1,800 Persons
33.	April 16, 1969 Lobdell, Louisiana	No Data
34.	April 16, 1969 Allentown Plant, Louisiana	150 Persons
35.	April 15, 1969 Allentown, Wisconsin	400 Persons
36.	April 21, 1969 Engle, Texas	No Data
37.	April 25, 1969 Pershing, Indiana	400 Persons
38.	May 7, 1969 Alhambra, Illinois	No Data
39.	May 15, 1969 Palmdale, California	No Data
40.	July 13, 1969 Preston, Louisiana	50 Persons
41.	July 13, 1969 Rexburg, Idaho	No Data
42.	July 17, 1969 Fackler, Alabama	12 Persons
43.	August 24, 1969 Piedmont, West Virginia	150 Persons
44.	September 3, 1969 Wellington, Alabama	200 Persons
45.	September 11, 1969 Glendora, Mississippi	10,000 Persons
46.	September 10, 1969 Butler, Illinois	700 Persons

47.	October 18, 1969 Troup, Texas	100 Persons
48.	May 16, 1969 Logansport, Louisiana	600 Persons
49.	November 30, 1969 Crew Lake, Louisiana	250 Persons
50.	November 26, 1969 Rockwell, Texas	200 Persons
51.	January 25, 1970 Elmira, New York	30 Families
52.	January 21, 1970 Belle, West Virginia	30 Families
53.	February 4, 1970 Sarah, Missouri	1 Family
54.	February 5, 1970 Calallen, Texas	1 Family
55.	March 3, 1970 Danbury, Texas	300 Persons
56.	March 11, 1970 Aurora, Nebraska	No Data
57.	April 9, 1970 New Athens, Illinois	1,500 Persons
58.	May 24, 1970 Jasper, Alabama	500 Persons
59.	June 21, 1970 Crescent City, Illinois	600 Persons
60.	July 6, 1970 Scotland, Illinois	No Data
61.	July 30, 1970 Walker, Louisiana	No Data
62.	August 14, 1970 Melvern, Kansas	50 Persons

63.	October 25, 1970 Farmers, Kentucky	1,000 Persons
64.	November 9, 1970 Batavia, New York	No Data
65.	December 2, 1970 Clay City, Illinois	100 Persons
66.	February 10, 1971 Ashkum, Illinois	2,500 Persons
67.	March 27, 1971 Panther Burn, Mississippi	250 Persons
68.	May 2, 1971 Eden, Mississippi	200 Persons
69.	May 5, 1971 Meridian, Mississippi	No Data
70.	August 18, 1971 Dudley, Iowa	No Data
71.	July 30, 1971 Bogota, New Jersey	No Data
72.	August 17, 1971 Dudley, Iowa	Few Families
73.	August 28, 1971 Cylon, Wisconsin	No Data
74.	September 18, 1971 Weston, Illinois	150 Persons
75.	December 3, 1971 Wheatfield, Indiana	700 Persons
76.	December 3, 1971 Thomasville, Alabama	112 Persons
77.	December 11, 1971 Corbin, Louisiana	500 Persons
78.	January 31, 1972 Staples, Louisiana	1 Family

79.	February 17, 1972 McKees Rock, Pennsylvania	6 Families
80.	February 16, 1972 Inverness, Texas	No Data
81.	March 18, 1972 Hammond, Pennsylvania	3 Families
82.	May 29, 1972 Ashmore, Illinois	25 Families
83.	May 14, 1972 Isleta, Ohio	1,100 Persons
84.	June 1, 1972 Dallas, Texas	100 Persons
85.	August 13, 1972 Huben, Oklahoma	No Data
86.	August 24, 1973 Columbus, Ohio	No Data
87.	September 5, 1972 College Park, Georgia	No Data
88.	October 2, 1972 Luka, Illinois	85 Persons
89.	October 24, 1972 Inman, California	30 Persons
90.	November 11, 1972 Burden, Kansas	No Data
91.	December 4, 1972 Edwardsville, Illinois	30 Families
92.	December 12, 1972 LaFollette, Tennessee	1 Family
93.	December 21, 1972 Luke, Maryland	18 Persons
94.	January 7, 1973 Page, Oklahoma	31 Persons
95.	February 5, 1973 Downington, Pennsylvania	700 Persons

FLORIDA

		Number Evacuated
1.	Tropical Storm Debbie Escambia, Santa Rosa, and Gulf Counties, FL 1965	1,600
2.	Flood Santa Rosa County, FL 1970	68
3.	Flood Okaloosa County, FL 1970	8 f
4.	Flood Lafayette County, FL August 27-28, 1970	21
5.	Chlorine Gas Incident Duval County, FL December 1967	20+
6.	Flood Clay County, FL 1969	20+
7.	Flood Clay County, FL 1971	20+
8.	Chemical Accident Lake County, FL Unknown	20+

f -- family

ALASKA

		Number Evacuated
1.	Earthquake Ketchikan, AK March 27, 1964	20+
2.	Windstorm Ketchikan, AK November 28, 1968	20+
3.	Earthquake; Tsunami Kodiak, AK March 27, 1964	20+
4.	Flood Anchorage, AK October 4, 1960	20+
5.	Flood Anchorage, AK January 30, 1961	20+
6.	Floods Anchorage, AK April 1962	20+
7.	Flood Anchorage, AK January 23, 1963	20+
8.	Fire Anchorage, AK February 21, 1963	20+
9.	Fire Cordova, AK May 1, 1963	20+
10.	Floods Anchorage, AK May 1963	20+

11.	Flood Anchorage, AK October 3, 1963	20+
12.	Floods Anchorage, AK May 31, 1964	20+
13.	Wind Disaster Anchorage, AK October 30, 1964	20+
14.	Flood Anchorage, AK September 5, 1964	20+
15.	Floods Anchorage, AK November 12, 1965	20+
16.	Earthquake Anchorage, AK March 27, 1964	20+
17.	Floods Anchorage, AK December 19, 1964	20+
18.	Fire Anchorage, AK September 12, 1966	20+
19.	Floods Anchorage Borough, AK May 21, 1964	20+
20.	Floods Anchorage Borough, AK May 17, 1968	20+
21.	Flood Kenai, AK January 18, 1969	20+

22.	Flood Anchorage, AK August 8, 1971	20+
23.	Earthquake Cordova, AK March 27, 1964	20+
24.	Fire Cordova, AK May 10, 1969	20+
25.	High Winds Cordova, AK October 7, 1969	20+
26.	Earthquake Seward, AK March 27, 1964	20+
27.	Earthquake Valdez, AK March 27, 1964	20+
28.	Floods Fairbanks, AK May 4, 1960	20+
29.	Floods Fairbanks June 27, 1961	20+
30.	Windstorms; Floods Fairbanks, AK August 1962	20+
31.	Floods Fairbanks, AK April 1962	20+
32.	Floods Fairbanks, AK May 1963	20+
33.	Floods Fairbanks, AK June 1964	20+

34.	Floods Fairbanks, AK May 27, 1965	20+
35.	Floods Tanana and Fairbanks, AK July 19, 1969	20+
36.	Apartment Fire Fairbanks, AK July 30, 1971	20+
37.	Floods St. Marys Area, AK June 1, 1972	20+
38.	Floods Kuskokwin-Bethal Area, AK May 1972	20+
39.	Floods Matanuska Area, AK August 13, 1971	20+
40.	Floods Fairbanks, AK June 9, 1971	20+

CALIFORNIA

		Number Evacuated
1.	Dam Collapse Baldwin Hills, CA December 14, 1963	8,000- 9,000
2.	Fires San Diego County, CA 1970	5,300
3.	Los Angeles Earthquake Los Angeles, CA February 9, 1971 (Van Norman Dam Evacuation)	85,000

COLORADO

		Number Evacuated
1.	Flood Brighton, OC June 1965	250
2.	Civil Disturbance Brighton, CO July 1972	100
3.	Flood Englewood, CO June 1965	60
4.	Flood Littleton, CO June 1965	250
5.	Flood Sheridan, CO June 1965	200
6.	Flood Unincorporated Area, Arapahoe County, CO June 1965	85
7.	Flood Unincorporated Area, Jefferson County, CO May 1969	125
8.	Flood Golden, CO June 1966	90
9.	Flood Unincorporated Area, Jefferson County, CO June 1965	50+
10.	Wind Storm Boulder, CO January 1972	240

11.	Flood Boulder, CO May 1969	25-50
12.	Flood Denver, CO June, 1965	125

IDAHO

		Number Evacuated
1.	Floods Bannock County, ID February 10, 1962	20+
2.	Floods Bannock County, ID February 1, 1963	20+
3.	Fire Bannock County, ID November 1963	20+
4.	Floods; Storms Bannock County, ID December 22, 1964	20+
5.	Floods; Storms Benewah County, ID December 22, 1964	20+
6.	Floods Bingham County, ID February 10, 1962	20+
7.	Floods Ada County, ID June 1967	20+
8.	Floods Bonneville County, ID February 10, 1962	20+
9.	Floods Bonneville County, ID December 22, 1964	20+
10.	Floods Bonneville County, ID December 20, 1968	20+

11.	Floods Caribou County, ID February 10, 1962	20+
12.	Floods Caribou County, ID February 1, 1963	20+
13.	Floods Clearwater County, ID June 1964	20+
14.	Floods; Storms Elmore County, ID December 22, 1964	20+
15.	Flood Fremont County, ID February 10, 1962	20+
16.	Floods Gooding County, ID February 1, 1963	20+
17.	Fire Idaho County, ID September 8, 1963	20+
18.	Floods Idaho County, ID June 1964	20+
19.	Floods Jefferson County, ID February 10, 1962	20+
20.	Flood Kootenai County, ID February 22, 1961	20+
21.	Floods Lemhi County, ID January 20, 1962	20+

22.	Floods Lemhi County, ID February 1, 1963	20+
23.	Floods Lemhi County, ID January 15, 1973	20+
24.	Floods Nez Perce County, ID February 1, 1963	20+
25.	Floods; Storms Nez Perce County, ID December 22, 1964	20+
26.	Floods; Storms Asotin County, ID December 22, 1964	20+
27.	Flood Madison County, ID February 10, 1962	20+
28.	Flash Flood Oneida County, ID August 28, 1961	20+
29.	Apartment Fire Shoshone County, ID January 7, 1960	20+
30.	Apartment Fire Shoshone County, ID February 22, 1964	20+
31.	Floods; Storms Shoshone County, ID December 22, 1964	20+
32.	Floods Power County, ID February 10, 1962	20+

33.	Floods Power County, ID February 1, 1963	20+
34.	Ice Jams; Floods Bingham County, ID December 18, 1972	20+
35.	Floods Latah County, ID January 1972	20+
36.	Ice Jams; Floods Bonneville County, ID January 24, 1969	20+
37.	Ice Jams; Floods Payette County, ID December 20, 1972	20+

KANSAS

		Number Evacuated
1.	Tornado Salina, KS June 21, 1969	60
2.	High Wind Sundowner East Trailer Court, Salina, KS April 30, 1972	35
3.	Tornado Simpson and Asherville, KS June 7, 1967	50
4.	Anhydrous Ammonia Tank Burst at Seam Beattie, KS August 19, 1968	300
5.	Flood Newton, KS June 1965	500- 600

KENTUCKY

		Number Evacuated
1.	Flood Middlesboro, KY July 24, 1965	200 f
2.	Flood Middlesboro, KY July 25, 1967	60 f
3.	Flood Harlan, KY March 7, 1967	150 f
4.	Flood Russellville, KY April 4, 1968	200 f
5.	Tornado Jessamine and Mason, KY April 23, 1968	40 f
6.	Flood Allen and Logan, KY June 23, 1969	50 f
7.	Flood Harlan County, KY December 30, 1969	357
8.	Flood Cane Run Dam, KY July 20, 1971	1,500
9.	Tornado Adair and Ohio, KY May 24, 1971	50
10.	Barge Accident Louisville, KY April 24, 1972	4,266

11.	Flood Frankfort, KY April 15, 1972	250 f
12.	Mud Slide Cumberland, KY December 14, 1972	32 f

MONTANA

		Number Evacuated
1.	Floods Beaverhead County, MT January 20, 1962	20+
2.	Floods Blaine County, MT March 18, 1969	20+
3.	Flood Blaine County, MT April 20, 1965	20+
4.	Floods Dawson County, MT February 19, 1971	20+
5.	Apartment Fire Butte County, MT October 2, 1967	20+
6.	Explosion; Fire Butte County, MT February 28, 1972	20+
7.	Ice Jams; Floods Gallatin County, MT January 30, 1969	20+
8.	Floods Cascade County, MT June 1964	20+
9.	Floods Cascade County, MT March 18, 1969	20+
10.	Apartment Fire Cascade County, MT January 8, 1971	20+

11.	Snowstorms; Winds Cascade County, MT February 10, 1972	20+
12.	Floods Custer County, MT March 18, 1969	20+
13.	Floods Dawson County, MT March 18, 1969	20+
14.	Floods Fergus County, MT June 1964	20+
15.	Flood Wheatland County, MT July 16, 1962	20+
16.	Floods Wheatland County, MT February 1, 1963	20+
17.	Floods Flathead County, MT June 1964	20+
18.	Floods Glacier County, MT June 1964	20+
19.	Snowstorms; Winds Glacier County, MT February 10, 1972	20+
20.	Hotel Fire Lewis & Clark County, MT April 28, 1965	20+
21.	Apartment Fire Lewis & Clark County, MT December 23, 1967	20+

22.	Hotel Fire Lewis & Clark County, MT March 13, 1968	20+
23.	Floods Lewis & Clark County, MT June 1964	20+
24.	Floods Big Horn County, MT February 27, 1962	20+
25.	Floods Big Horn County, MT May 21, 1962	20+
26.	Floods Big Horn County, MT June 1967	20+
27.	Floods Big Horn County, MT March 18, 1969	20+
28.	Apartment Fire Yellowstone County, MT January 23, 1971	20+
29.	Explosion; Fire Mineral County, MT March 29, 1962	20+
30.	Train Wreck Mineral County, MT June 10, 1962	20+
31.	Bus Wreck Mineral County, MT December 31, 1962	20+
32.	Apartment Fire Missoula County, MT September 5, 1965	20+
33.	Apartment Fire Missoula County, MT June 6, 1965	20+

34.	Flood Phillips County, MT April 20, 1965	20+
35.	Floods Pondera County, MT June 1964	20+
36.	Floods Powell County, MT June 1964	20+
37.	Floods Teton County, MT June 1964	20+
38.	Floods Toole County, MT June 1964	20+
39.	Floods Toole County, MT June 16, 1965	20+
40.	Fire; Forest Fire Valley County, MT September 12, 1971	20+
41.	Floods Ravelli County, MT June 12, 1972	20+
42.	Floods Rosebud County, MT April 16, 1971	20+

NORTH DAKOTA

		Number Evacuated
1.	Flood Minot, ND April 1969	12,000
2.	Flood Belfield, ND 1970	40
3.	Flood Velva, ND 1962	400
4.	Flood Mandan, ND 1971	50
5.	Flood Glen Ullin, ND 1966	70
6.	Flood Glen Ullin, ND 1967	50
7.	Flood Hebron, ND 1971	50
8.	Flood Hebron, ND 1972	60
9.	Flood Pembina, ND 1969	40
10.	Flood Grafton, ND April 1965	60

11.	Flood Grand Forks, ND April 1965	200
12.	Flood Grand Forks, ND 1966	300
13.	Flood Hillsboro, ND 1967	30
14.	Flood Hillsboro, ND 1968	30
15.	Flood Fargo, ND April 1965	60
16.	Flood Fargo, ND March 1966	60
17.	Flood Fargo, ND April 1969	60
18.	Flood Jamestown, ND April 1966	280
19.	Flood Jamestown, ND April 1969	350
20.	Flood Enderlin, ND 1969	50
21.	Flood Enderlin, ND 1970	35

22.	Flood Fairmont, ND 1964	35
23.	Flood Mott, ND 1972	40
24.	Flood Neche, ND 1969	35
25.	Flood Mayville, ND 1967-1968	30
26.	Tornado Courtney, ND June 1967	40

OHIO

		Number Evacuated
1.	Truck Fire Sharonville, OH July 27, 1968	Unknown
2.	Tornadoes Northern Ohio July 4-5, 1969	Unknown
3.	Oil Line Rupture Lima, OH January 13, 1969	2,000
4.	Toxic Fume -- Burning Freight Car Coshocton, OH May 16, 1972	100 f
5.	Storm on Lake Erie; Hurricane Agnes Belmont, Cuyahoga, Jefferson, Lake, Lorain, Ashtabula, and Monroe Counties June 23-27, 1972	185
6.	Severe Rainstorms; Flash Flooding Hicksville, OH September 13, 1972	38-80 f
7.	Severe Storms; Flooding Ashtabula, Cuyahoga, Erie, Lake, Lorain, Lucas, Ottawa, and Sandusky Counties November 14-16, 1972	2,500
8.	Train Derailment -- Explosion and Fire Harrod, OH January 4, 1973	100
9.	Severe Storms; Flooding Ashtabula, Cuyahoga, Erie, Lake, Lorain, Lucas, Ottawa, and Sandusky Counties March 17-19, 1973; April 9-10, 1973	1,000

OREGON

		Number Evacuated
1.	Flood Baker County, OR February 1, 1963	20+
2.	Windstorm Benton County, OR October 12, 1962	20+
3.	Floods; Storms Benton County, OR December 22, 1964	20+
4.	Storms Clatsop County, OR October 1962	20+
5.	Tidal Wave Clatsop County, OR March 28, 1964	20+
6.	Floods; Storms Clatsop County, OR December 22, 1964	20+
7.	Windstorms Clatsop County, OR December 2, 1967	20+
8.	Floods Clatsop County, OR January 8, 1971	20+
9.	Floods; Windstorms Clatsop County, OR January 11, 1972	20+
10.	Fire Coos-Curry County, OR February 20, 1960	20+

11.	Tugboat Disaster Coos-Curry County, OR February 20, 1960	20+
12.	Storms Coos-Curry County, OR October 1962	20+
13.	Tidal Wave Coos-Curry County, OR March 28, 1964	20+
14.	Floods; Storms Coos-Curry County, OR December 22, 1964	20+
15.	Hotel Fire Coos-Curry County, OR December 16, 1970	20+
16.	Floods; Storms Crook County, OR February 22, 1964	20+
17.	Floods; Storms Deschutes County, OR December 22, 1964	20+
18.	Floods Douglas County, OR February 12, 1961	20+
19.	Floods Douglas County, OR December 22, 1964	20+
20.	Floods Douglas County, OR January 3, 1966	20+
21.	Floods Grant County, OR December 23, 1964	20+

22.	Rainstorms Grant County, OR June 1969	20+
23.	Floods; Storms Harney County, OR December 22, 1964	20+
24.	Floods; Storms Hood River County, OR December 22, 1964	20+
25.	Freeze Hood River County, OR January 21, 1969	20+
26.	Floods Jackson County, OR December 1, 1962	20+
27.	Storms Jackson County, OR October 1962	20+
28.	Hailstorm Jackson County, OR July 13, 1964	20+
29.	Floods; Storms Jackson County, OR December 22, 1964	20+
30.	Windstorms Josephine County, OR October 1962	20+
31.	Floods; Storms Jefferson County, OR December 22, 1964	20+
32.	Floods; Storms Josephine County, OR December 1964	20+

33.	Floods; Storms Klamath County, OR December 22, 1964	20+
34.	Floods; Storms Lake County, OR December 22, 1964	20+
35.	Hotel Fire Lane County, OR March 2, 1960	20+
36.	Floods Lane County, OR February 10, 1961	20+
37.	Storms; Floods Lane County, OR December 22, 1964	20+
38.	Storms; Floods Lane County, OR February 10, 1962	20+
39.	Freeze; Floods Lane County, OR December 26, 1968	20+
40.	Floods Lane County, OR February 1973	20+
41.	Floods; Storms Lincoln County, OR March 8, 1960	20+
42.	Storms Lincoln County, OR October 1962	20+
43.	Floods; Storms Lincoln County, OR December 22, 1964	20+

44.	Floods; Storms Lincoln County, OR January 11, 1972	20+
45.	Storms Linn County, OR October 1962	20+
46.	Floods; Storms Linn County, OR December 22, 1964	20+
47.	Rainstorms Morrow County, OR June 1969	20+
48.	Flash Flood Morrow County, OR May 24, 1971	20+
49.	Floods Clackamas County, OR November 24, 1960	20+
50.	Floods Clackamas County, OR February 12, 1961	20+
51.	Storms; Winds Columbia County, OR October 1962	20+
52.	Floods Multnomah County, OR November 24, 1960	20+
53.	Apartment Fire Multnomah County, OR January 12, 1962	20+
54.	Apartment Fire Multnomah County, OR January 6, 1963	20+

55.	Apartment Fire Multnomah County, OR March 12, 1965	20+
56.	Apartment Fire Multnomah County, OR January 20, 1963	20+
57.	Storms Multnomah County, OR December 22, 1964	20+
58.	Freeze; Floods Multnomah County, OR December 20, 1968	20+
59.	Fire Multnomah County, OR July 15, 1971	20+
60.	Apartment Fires Multnomah County, OR October 1972	20+
61.	Apartment Fire Multnomah County, OR January 1973	20+
62.	Storms; Winds Washington County, OR October 1962	20+
63.	Hotel Fire Washington County, OR January 1963	20+
64.	Apartment Fire Washington County, OR January 1963	20+
65.	Floods Washington County, OR January 22, 1970	20+
66.	Apartment Fire Washington County, OR November 4, 1969	20+

67.	Storms; Winds Yamhill County, OR October 1962	20+
68.	Windstorms; Floods Yamhill County, OR December 1964	20+
69.	Windstorms; Floods Sherman County, OR December 1964	20+
70.	Windstorms; Floods Tillamook County, OR December 1964	20+
71.	Floods Tillamook County, OR December 8, 1971	20+
72.	Floods; Rainstorms Tillamook County, OR January 1972	20+
73.	Fire Umatilla County, OR January 18, 1960	20+
74.	Apartment Fire Umatilla County, OR May 13, 1963	20+
75.	Storms; Floods Umatilla County, OR December 22, 1964	20+
76.	Storms; Floods Union County, OR December 22, 1964	20+
77.	Fire Wasco County, OR August 19, 1962	20+
78.	Floods; Storms Wasco County, OR December 22, 1964	20+

79.	Floods Marion County, OR November 24, 1960	20+
80.	Storms; Rain Marion County, OR October 1962	20+
81.	Floods; Rainstorms Polk County, OR December 22, 1964	20+

SOUTH CAROLINA

		Number Evacuated
1.	Ice Storm Pee Dee Area, SC February 15, 1971	Unknown
2.	Train Wreck Ulmers, SC May 30, 1964	Unknown
3.	Snow Storm Allendale County, SC February 1973	Unknown
4.	Tornado Allendale County, SC 1970	Unknown
5.	Hurricane Allendale County, SC 1959-1960	Unknown
6.	Hurricane Seabrook Island, SC September 19, 1959	52 f
7.	Flood Horry County March 1, 1973	10 f
8.	Chemical Accident Newberry County, SC December 8, 1972	2 f
9.	Chemical Accident Carlisle, SC December 29, 1969	400- 450
10.	Flood Aiken, SC April 16, 1969	20- 25 f

11.	Flash Flooding Anderson, SC July 9, 1968	50 f
12.	Tropical Storm Flooding Beaufort County, SC August 19, 1971	Unknown
13.	Snow Storm Beaufort County, SC February 10, 1973	Unknown
14.	Ruptured Gas Main Charleston, SC February 19, 1973	570 f
15.	Tank Car of Ammonia Ruptured Daniel Jenkins Homes, SC	20 f
16.	Hurricane Bennetts Point, SC Fall of 1963 or 1964	Unknown
17.	Flooding Darlington County, SC January 10, 1973	7 f
18.	Fire -- Gasoline Tanker Harleyville, SC November 19, 1971	
19.	Flooding Florence County, SC February 3-4, 1973	5 f
20.	Heavy Rains; Flooding Conway and Garden City, SC August 1971	20-30 f
21.	Heavy Rains; Flooding Conway and Garden City, SC February 1973	50 f

22.	Chemical Accident Lancaster County, SC April 28, 1973	30
23.	Flooding Brittons Neck and Sellers Area, SC September 1969	12 f
24.	Flooding Little Pee Dee River, Nichols, SC October 1968	6 f
25.	Chemical Accident Newberry, SC December 8, 1972	2 f
26.	Train Wreck Whitmire, SC Unknown Date	Unknown
27.	Gas Line Break Richland County, SC 1966	200
28.	Trailer-Truck Fire -- Toxic Chemicals Richland County, SC 1972	10
29.	Train Wreck Switzer, SC July 1967	30 f
30.	Railway Chemical Tank Leak Inman, SC October 1972	25 f
31.	Propane Gas Fire Sumter County, SC November 2, 1971	50 f
32.	Fire Sumter County, SC February 10-12, 1973	8 f

33.	Flood Kingstree, SC July 1965	8 f
34.	Flash Flooding Rock Hill, SC April 1969	10 f
35.	Chemical Accident Rock Hill, SC August 16, 1971	10 f 1,000

WASHINGTON

		Number Evacuated
1.	Forest Fire Apple Valley, WA August 8, 1968	20+
2.	Hotel Fire Benton County, WA December 3, 1970	20+
3.	Freeze; Floods Franklin County, WA December 20, 1968	20+
4.	Flash Flood Franklin County, WA February 12, 1969	20+
5.	Flood Clallam County, WA January 16, 1961	20+
6.	Explosion; Fire Clallam County, WA October 1, 1971	20+
7.	Storms Clark County, WA October 1962	20+
8.	Storms; Floods Clark County, WA December 22, 1964	20+
9.	Tornado Clark County, WA April 5, 1972	20+
10.	Storms; Floods Columbia County, WA December 22, 1964	20+

11.	Storms; Floods Cowlitz County, WA December 1962	20+
12.	Storms; Floods Cowlitz County, WA December 22, 1964	20+
13.	Floods Cowlitz County, WA January 22, 1972	20+
14.	Flash Flood Garfield County, WA September 13, 1966	20+
15.	Floods Garfield County, WA January 8, 1971	20+
16.	Explosion Grant County, WA September 25, 1963	20+
17.	Flood; Windstorms Grant County, WA January 11, 1972	20+
18.	Fire Grays Harbor County, WA July 1, 1967	20+
19.	Apartment Fire Grays Harbor County, WA October 22, 1967	20+
20.	Apartment Fire Grays Harbor County, WA June 9, 1971	20+
21.	Floods; Windstorms Grays Harbor County, WA January 11, 1972	20+

22.	Floods Grays Harbor County, WA December 22, 1972	20+
23.	Explosion Spokane County, WA July 13, 1962	20+
24.	Apartment Fire Spokane County, WA November 19, 1964	20+
25.	Hotel Fire Spokane County, WA July 8, 1965	20+
26.	Fire Spokane County, WA July 1967	20+
27.	Apartment Fire Spokane County, WA April 10, 1970	20+
28.	Fire (Washington State University) Spokane County, WA April 14, 1971	20+
29.	Fire Spokane County, WA April 23, 1971	20+
30.	Hotel Fire Spokane County, WA June 9, 1971	20+
31.	Rainstorms; Windstorms Kitsap County, WA October 1962	20+
32.	Hotel Fire Kitsap County, WA March 30, 1965	20+

33.	Earthquake Kitsap County, WA April 29, 1965	20+
34.	Floods Kitsap County, WA January 3, 1966	20+
35.	Explosion; Fire Kittitas County, WA April 2, 1962	20+
36.	Hotel Fire Kittitas County, WA November 24, 1967	20+
37.	Floods; Windstorms Klickitat County, WA December 22, 1964	20+
38.	Rain; Windstorms Lewis County, WA October 1962	20+
39.	Floods; Windstorms Lewis County, WA January 11, 1972	20+
40.	Floods Okanogan County, WA May-June 1972	20+
41.	School Fire Seattle-King County, WA March 2, 1962	20+
42.	Hotel Fire Seattle-King County, WA January 29, 1963	20+
43.	Earthquake Seattle-King County, WA April 29, 1965	20+

44.	Hotel Fire Seattle-King County, WA October 19, 1966	20+
45.	Apartment Fire Seattle-King County, WA October 18, 1963	20+
46.	Hotel Fire Seattle-King County, WA November 17, 1967	20+
47.	Apartment Fire Seattle-King County, WA December 15, 1967	20+
48.	Apartment Fire Seattle-King County, WA July 31, 1969	20+
49.	Hotel Fire Seattle-King County, WA December 8, 1969	20+
50.	Apartment Fire Seattle-King County, WA October 17, 1969	20+
51.	Tornado Seattle-King County, WA December 12, 1969	20+
52.	Apartment Fire Seattle-King County, WA January 8, 1970	20+
53.	Rooming House Fire Seattle-King County, WA March 22, 1970	20+
54.	Hotel Fire Seattle-King County, WA March 20, 1970	20+

55.	Apartment Fire Seattle-King County, WA June 14, 1970	20+
56.	Apartment Fire Seattle-King County, WA April 25, 1971	20+
57.	Apartment Fire Seattle-King County, WA January 8, 1972	20+
58.	Apartment Explosion Seattle-King County, WA February 17, 1972	20+
59.	Floods Seattle-King County, WA March 5, 1972	20+
60.	Floods; Windstorms Seattle-King County, WA January 11, 1972	20+
61.	Hotel Fire Skagit County, WA July 9, 1969	20+
62.	Floods Snohomish County, WA December 24, 1967	20+
63.	Floods Snohomish County, WA January 8, 1971	20+
64.	Apartment Fire Snohomish County, WA September 26, 1971	20+
65.	Floods; Windstorms Snohomish County WA January 11, 1972	20+

66.	Apartment Fire Pierce County, WA July 25, 1960	20+
67.	Hotel Fire Pierce County, WA December 7, 1964	20+
68.	Earthquake Pierce County, WA April 29, 1965	20+
69.	Apartment Fire Pierce County, WA May 2, 1969	20+
70.	Apartment Fire Pierce County, WA May 10, 1971	20+
71.	Floods Pierce County, WA March 5, 1972	20+
72.	Earthquake Thurston County, WA April 28, 1965	20+
73.	Apartment Fire Thurston County, WA February 12, 1968	20+
74.	Floods Thurston County, WA March 5, 1972	20+
75.	Floods; Windstorms Thurston County, WA January 11, 1972	20+
76.	Floods Chelan County June 13, 1972	20+

77.	Floods; Flash Floods; Rain Douglas County, WA June 1972	20+
78.	Floods; Storms Walla Walla County, WA December 22, 1964	20+
79.	Flood Whatcom County, WA January 15, 1961	20+
80.	Apartment Fire Whatcom County, WA August 18, 1963	20+
81.	Floods Whatcom County, WA December 13, 1966	20+
82.	Floods Whatcom County, WA December 24, 1964	20+
83.	Hotel Fire Whatcom County, WA November 4, 1968	20+
84.	Freeze; Floods Whatcom County, WA December 20, 1968	20+
85.	Apartment Fire Whatcom County, WA June 14, 1969	20+
86.	Floods Whatcom County, WA January 8, 1971	20+
87.	Floods Whitman County, WA February 1, 1963	20+
88.	Windstorms Whitman County, WA January 11, 1972	20+

89.	Floods; Storms Yakima County, WA December 22, 1964	20+
90.	Freeze; Floods Yakima County, WA December 20, 1968	20+
91.	Hotel Fire Yakima County, WA December 20, 1970	20+
92.	Floods Yakima County, WA January 8, 1971	20+
93.	Hotel Fire Yakima County, WA January 1972	20+

WYOMING

	Number Evacuated
1. Flooding Fremont County -- Lander and Shoshone February and March 1963	25+
2. Flooding Uinta County -- Mountain View, Fort Bridger, Lone Tree, and Evanston 1963, 1965, and 1968	25+

APPENDIX H

CHI SQUARE TEST OF TABLE 1 DATA

The Chi Square Test is made since it can be shown that the miles driven per day per person is essentially the same during an evacuation and during everyday normal driving.

CHI SQUARE TEST

	DEATHS	NON-DEATHS	TOTAL
National	5.47×10^4	2.19×10^8	2.19×10^8
EPA	2	1.13×10^6	1.13×10^6
Totals:	5.47×10^4	2.20×10^8	2.20×10^8

$$\chi^2 = \frac{(6.18 \times 10^{10} - 4.38 \times 10^8)\ (2.20 \times 10^8)}{(2.19 \times 10^8)(5.47 \times 10^4)(2.20 \times 10^8)(1.13 \times 10^6)}$$

$$\chi^2 = \frac{8.28 \times 10^{29}}{2.98 \times 10^{27}}$$

$$\chi^2 = 278$$

Null Hypothesis: probability of deaths during an evacuation is not different from the normal probability of traffic deaths.

For one degree of freedom, the critical value of χ^2 for $\alpha = .05$ is >3.84146. Since the observed value of χ^2 is 278, we reject the null hypothesis.

Although it appears that there is a real difference between the national average death rate and that of evacuees, the small number of deaths (two) observed in the evacuation study is low enough to cast some doubt on the validity of applying any statistical operation. Furthermore, the circumstances surrounding the two deaths suggest they are not typical highway incidents. In order to be able to meaningfully apply a statistical analysis, the study should be expanded by one or two orders of magnitude. In other words, we should observe 20 to 200 deaths in order to compare the two death rates. If the observed death rate is correct, it would be necessary to study an additional 10^7 to 10^8 persons during evacuation. It is very unlikely that any population approaching this magnitude has been evacuated -- certainly not within the past 13 years. It is therefore recommended that the estimated death rates not be considered different from the normal death rates, or at least that a great deal of precaution be taken to make clear the doubtfullness of their validity.

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